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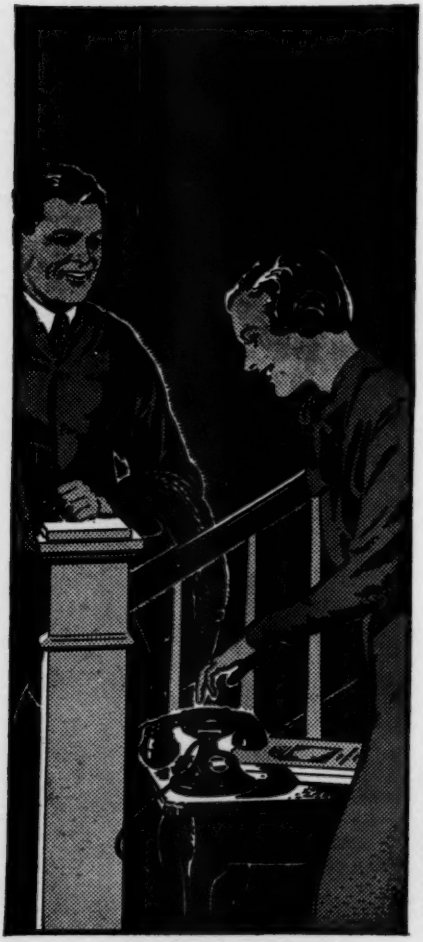

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THE CORNELL MEETING

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The 42nd annual meeting will be held at Cornell University on June 19–23, 1934. There will be numerous conferences or seminars on Tuesday all day, Wednesday all day, and Thursday morning, June 19, 20 and 21. The general sessions will be held on Thursday afternoon, Friday, and Saturday morning, June 21, 22 and 23.

Especial attention is called to the conferences, a partial list of which appeared in the March Journal. The aim of each conference or seminar is to bring together a group of men who are doing pioneer work for a pooling of experience and for mutual guidance and stimulation. We are planning to print programs of many of these conferenees in the June Journal.

The theme of the general meeting will be "Reconciling the Professional and General Aspects of Engineering Education." On Friday morning there will be symposium on "Marketing the Graduate's Services"; in the afternoon, there will be reports from the conferences and committees, followed by the annual dinner; and on Saturday morning the topic of discussion will be "Professional Recognition and Educational Standards."

The tentative program of this meeting was mailed to all members the first of May. If you have not received your copy, or desire additional copies, please notify this office. A reservation card was included in the program and the Local Committee requests early reservations in order to make the proper accommodations for you.

SHOULD ENGINEERING PROFESSORS PRACTICE ENGINEERING?

By G. M. BUTLER

Dean, College of Mines and Engineering, University of Arizona

With thousands of engineers unemployed and many of them suffering real privation, it is perhaps not surprising that several protests should have been recently voiced at the prevailing practice of permitting and even encouraging instructors of engineering, employed on full-time bases, to engage in commercial engineering during their spare time. The writer was recently permitted to read such a protest, and was so impressed by the ignorance and bias of the protestant that he thought many practicing engineers might be equally unfamiliar with the situation and might be interested in the professor's side of the question which he will attempt to set forth.

The Present Situation

In the report on the investigation of engineering education made under the auspices of the Society for the Promotion of Engineering Education in 1925, it is stated that 111 of the 116 institutions investigated, or 96 per cent, *permitted* engineering teachers to engage in professional practice during the academic year, and that 76 of these institutions *encouraged* such instructors to do so. It is doubtful if there has been any material change in the situation during the past seven years, so it is evident that the practice which some engineers criticise is almost universally followed.

Of course, the mere fact that a certain thing is being done, and has been done for years, does not *prove* that the practice is right and just, but, if the procedure is almost universally followed, there is then strong presumptive evidence that it has merit, and the wise man will not criticise it unless fully informed concerning the practice and its effects upon all concerned.

Seriousness of Competition by Professors

From the report of the Society for the Promotion of Engineering Education, to which reference is already made, we learn that, in 1924, 1,775 engineering instructors had incomes exclusive of their salaries, and that the aggregate of these incomes amounted to $1,485,205 or an average of $836 per man. These men had

taught from one to forty-five years, and it is inconceivable that they had saved nothing and had no other resources of income excepting professional practice. It is, however, utterly impossible to ascertain what proportion of this supplementary income was derived from professional practice and what part from savings, lecture fees, royalties on books, etc. From nearly thirty years of experience as an instructor and dean in engineering schools, the writer believes that he is being very conservative when he estimates that one half of this supplementary income, $742,000 in round numbers, was derived from fees for professional services.

$742,000 is certainly a considerable sum of money, but it would not go far if divided among all the non-teaching engineers in this country. It is impossible to ascertain how many men might share in this distribution, but it is a fact that the 1931 Yearbooks of the four "Founder Societies" show that they then had 25,526 members, honorary members, and fellows on their rolls. If it is assumed that their growth had been twenty per cent in the preceding seven years (the increase has probably been less), they had 22,973 members of the grades mentioned in 1924. If we also assume that each of the 1,175 engineering instructors was a member of one of the "Founder Societies" (which is, unfortunately, not true of many of these men), there were 21,198 non-teaching members of the grades mentioned in 1924, and, if $742,000 had been equally divided among them, each would have received $35.00. Of course, a small proportion of these men are not citizens of our country, but it is certainly true that there were more Associate and Junior members of these societies who were seeking engineering service for fees than there were foreign members.

Of course, some of the Founder Society members considered in this computation were working for salaries and were probably not available for the jobs done by the engineering instructors, but who could doubt that for each such member there existed several engineers who did not belong to any of the Founder Societies.

The unknown factors are so many, that it is evidently impossible to arrive at any exact figures, but the writer feels positive that he is being very conservative when he makes the statement that, in 1924, if the teaching engineers had done no professional work for fees, the non-teaching engineers in the country would have benefited, on the average, to the extent of less than $25, each, a year.

Of course, each non-teaching engineer would not have received $20 or $15 or whatever his theoretical share would have been if the professors were not practicing. Some engineers would have had their incomes augmented by several hundred or even a thousand or more dollars, while most of the others would not have benefited

at all. It is also generally true that those who would have most benefited if the competition of the engineering teachers had been eliminated were successful men of established reputations who could best afford to sacrifice a part of their potential incomes in order that others might be materially benefited. Whether others were so benefited will be considered later.

The country was relatively prosperous in 1924 and much engineering work was available. There is certainly little work, excepting "relief" work, to be done now, but it should be remembered that the engineering instructors are also doing far less professional work for fees now than they did in 1924. During the past year, the writer's income from these fees was less than twenty per cent of what it was a few years ago. It is unlikely that all the engineering instructors together have earned $100,000 in this way during the past year. If that sum were divided among all the non-teaching engineers, it would not buy "smokes" for them for more than a few days. The fact is that, no matter what reasonable assumptions are made, the professional work for fees done by engineering instructors is a mere drop in the bucket and during this time of depression has approached close to the vanishing point. It is extremely unlikely that those who have protested most vigorously at the unfairness of the practice under consideration would notice a particle of change in their financial situation if every instructor were forbidden to accept fees for his professional services. Far from being serious, the effect of the practice criticized upon the welfare of non-teaching engineers is trivial and inconsequential.

Is the Practice Criticized Wrong?

Those engineers who criticize engineering instructors for practicing professionally claim that men employed on a full-time basis for teaching and research have no right to compete professionally with non-teaching engineers and that, if they do so, they will be competing with their own students after they graduate, which the critics claim is unfair. Let us briefly consider these contentions, recognizing that, even if the practice under consideration does not interfere seriously with the earnings of non-teaching engineers, it should not be followed if morally reprehensible.

All will probably admit that teachers in endowed institutions and part-time instructors in tax-supported colleges have a perfect moral and legal right to practice for fees. If the boards of control of endowed colleges do not object to the practice, no one else has a right to do so. It will also probably be admitted that engineering instructors who are not paid during their summer vacations are free to accept any employment they can secure then. How about

the full-time engineering instructors in tax-supported institutions who practice during the academic year, however? They are the class who must bear the brunt of the criticism.

In the first place, let it be noted that few American institutions, other than the Government itself, actually profess to buy the "full time" of any American citizen so far as forbidding him to do remunerative work in order to supplement his salary, and even our Government does not attempt to prevent postmasters of first-class offices, who are supposedly appointed on a full-time basis, from carrying on some business "on the side."

It is a fact that engineering instructors are appointed and required to do certain things—teach certain courses and do or direct a certain amount of research work which it is estimated will fill not over eight hours each week day, with a half holiday on Saturday. Any time remaining, including Sundays, holidays, and Saturday half holidays, is everywhere recognized as just as much at the disposal of the instructor as it is in the cases of practically all other salaried people. Of course, expediency will cause the instructor to live morally and will probably cause him to refrain from political activities, but, otherwise his spare time is and certainly should be his own. Who objects when a professor of English writes a successful book or play, even though he is certainly then competing with other authors and playwrights? A "full time" professor of mathematics, who was well known to the writer, owned and ran a dairy branch during his spare time, and no one criticized him as doing anything wrong or unfair. Full-time professors of music frequently write and sell musical compositions during their spare time without criticism. Indeed, their advancement is often considerably dependent upon the amount of such work that they do. Many "full time" professors invent machines and processes and market them profitably. It is true that some of them dedicate such inventions to the public, but they are rarely criticized if they fail to do so. Many professors receive fees of respectable size for addresses or lectures, thereby competing with lawyers, ministers, and other orators, but no one complains.

One could easily fill a long article by mentioning the many things that "full time" professors in tax-supported institutions have done and are doing to create incomes to supplement their salaries, which activities, in the great majority of instances, make them competitors of people who are paid nothing by the state. It could further be shown that they do these things without incurring criticism since the public generally seems to understand that, unless an instructor's activities are circumscribed in some way by the terms of his contract, his spare time is and should be his own to use as his needs and good sense dictate.

Certainly an engineering professor has just as much right to practice his profession in his spare time as a professor of horticulture has to set out and develop an orchard, the produce of which will seriously compete with that of owners of other orchards. The truth is, of course, that both are acting within their rights and should not be criticized. If the time ever comes when the law or customs prevents the ambitious salaried man from earning more than his salary, even though that salary is paid by the state, then will the lot of such men be sad indeed, and only the mediocre among our people will be willing to fill salaried positions.

If it is not morally wrong for engineering instructors to practice professionally, is it in poor taste, or, in some obscure way, unethical for them to compete with their own graduates?

The persons who ask this question apparently do not realize that the engineering instructors, as well as most other teachers, are underpaid and that, in normal times, the earnings of the average engineering instructor, including his professional fees, amount to less than the earnings of the average non-teaching graduate.

The report of the Society for the Promotion of Engineering Education, already mentioned, shows that, in 1924, the average income of an engineering professor who had taught ten years was 77.5 per cent of the average income of the non-teaching graduates who had been practicing for the same length of time. Thirty years after graduation, the instructor's income had decreased to 74 per cent of that of the non-teaching engineer.

Unless, then, the average salary of engineering instructors is increased about 33 per cent, his graduates, in normal times, will be better off financially even if the teachers continue to accept professional employment in competition with non-teaching engineers. During depressions, of course, the average salary of engineering instructors may equal or even exceed the average salary of non-teaching engineers, but depressions as a whole have been much shorter than periods of prosperity, and the engineering instructors do so little professional work during the periods of depression that the effect is inconsequential, as has been stated.

Suppose, however, that the tax-paying engineer says: "I do not care whether the practice I condemn is right or wrong or just how seriously it may affect me. Even if I lose only twenty-five dollars a year, I do not like it. I pay taxes that provide the salaries of these professors, and I have a right to dictate what they shall and shall not do. I am going to kick and keep on kicking until the practice is abolished."

It is doubtful if such an engineer has ever really considered just how small a financial contribution he makes to professors' salaries. Last year, in Tucson, Arizona, for instance, the tax rate

for all purposes was $0.046. Of this amount, the University of Arizona received less than $0.0015. Eight and eight tenths per cent of the money given to the University was used to pay the salaries of all the instructors, twenty-eight in number, of the College of Mines and Engineering. If, then, a non-teaching engineer owned property assessed at $10,000 (which, unfortunately, was true in a few instances), he paid $460 in taxes, and of this amount, he contributed $1.33 toward the salaries of *all* the engineering instructors in the state. It is probable that the contribution of the average engineer was less than half this amount, and that the sum he gave toward the salary of the professor or professors who might be considered competing with him would not buy a good cigar.

While the figures given will, of course, vary in other states, they will be of the same order or magnitude, and conclusively demonstrate that the great majority of the non-teaching engineers each contributes in taxes toward the payment of engineering instructors' salaries a sum so insignificant as to give him no right whatever to dictate what these professors shall or shall not do.

Effect upon Engineering Colleges of Proffessional Practice by Engineering Instructors

Although many attacks upon our higher educational institutions have been made during recent years, a careful perusal of most of them reveals the fact that they are not directed against professional schools and certainly not against engineering colleges. In fact, the latter occupy an enviable position in the educational world. Very few of them make any attempt artificially to stimulate attendance through advertising or other means. Indeed, through orientation courses, entrance requirements more severe than are demanded for admission to other colleges, heavy schedules, and high standards, most engineering colleges conscientiously and actively attempt to discourage unfit students from entering or remaining in them. Most of our graduates are, therefore, picked men of exceptional ability who are determined to become engineers in spite of the drawbacks and discouragements that surround the profession with which the students are early familiarized. In training these young men, great emphasis is placed upon fundamentals and little upon specialization. As a result of these policies and the high quality of the instruction given in most engineering colleges, the graduates have been eagerly sought by the industries and have made notable successes therein. Indeed, in normal times, the demand has often been greater than the supply. Of course, there is little or no demand for engineering graduates now, except for "relief" work, but there is little permanent demand for any worker, trained or

untrained. Sane men believe, however, that prosperity will return when our people have learned the bitter lessons resulting from their own foolishness.

It has been intimated that the splendid record made by engineering graduates is in part due to the excellent training they received from their engineering instructors. Probably all administrative officers of engineering colleges, as well as many successful practicing engineers, are absolutely convinced that the high average quality of the instruction given is largely due to the fact that the instructors are, in many instances, both teachers and practicing engineers. Indeed, most executives of engineering colleges would prefer to have few men on their faculties, teaching engineering subjects, who lack the ability or the inclination to engage in professional work in their spare time.

There was a time when college professors were generally regarded as theorists and academicians solely—impractical beings who spent most of their time delving in musty tomes. Possibly there was once considerable justification for this idea, and it may be true of some professors now, but it certainly is not generally true of engineering instructors. They are active in technical societies, and their colleagues in such organizations respect their ability and recognize that they are practical men. They are often leaders in their communities, head civic organizations and commissions of various kinds, and have certainly deserted the cloistered world once supposed to be their habitat. The fact that they have done so has greatly increased the respect with which they and their profession is held, and has undoubtedly had a very favorable effect upon their work as teachers.

Engineers, like doctors, are interested in *applied* science; they are inherently doers rather than theorizers. A large proportion of the professors of medical subjects will accept only part-time appointments in order that they can at the same time handle large practices. Few really good doctors would accept teaching positions under any other conditions.

Most good engineers are actuated by the same sentiments. Unless they can get out into the field occasionally and actually practice engineering, they are unhappy and dissatisfied. Most high-class engineers simply will not sacrifice such opportunities, and would, in normal times scoff at the offer of a teaching position which did not permit them to practice to some extent at the same time.

Administrative officers of engineering colleges have learned by observation and experience that nothing is more effective in keeping engineering instructors "up to date" in the subjects they teach than is the knowledge that they may at any time be called upon

to prove their mastery of these subjects in the field. Moreover, the courses taught by men who do practice professionally are continually being enriched with illustrative material gathered during their extra-class activities, and their lectures are inspiring because the ideas they seek to convey are based on personal experience, not on textbooks and articles which may be read by anyone. Then, too, occasional professional engagements are very welcome breaks in routine, which refresh the instructors who secure them. They come back to their classrooms with renewed interest in and enthusiasm for their work.

The writer is completely convinced that to deny engineering instructors the right to engage in professional practice during their spare time would be nothing less than a major catastrophe for the profession and for engineering colleges. During normal times their faculties would then consist predominately of men who lack sufficient initiative, forcefulness, and ability to succeed as practicing engineers, men who have never dared to try to compete with other engineers, or who have tried and failed. Do we wish such men to endeavor to train our sons? Will they be able to direct future engineers out of the "sloughs of despond" that beset engineers and engineering? Can we justly hope that engineering knowledge will be advanced by them?

Desirable Safeguards

While most engineering instructors are reasonable men who do not abuse the privilege of doing professional work in their spare time, it is probably desirable to regulate the practice in order to avoid the possibility of trouble. At the University of Arizona, the following regulations are in force:

1. An instructor's first duty is to the University, and he is not permitted to accept work which will interfere with his routine duties. He must discuss the matter with his Dean or the President of the University, and secure approval of the project before he accepts any offer. He is not permitted to accept a permanent position as consultant or advisor of any company until he has obtained the approval of the Board of Regents.

2. The fee he demands must be at least as high as most reputable engineers of similar training and experience obtain, and it should preferably be higher.

3. He must accept no work that might in any way have a detrimental effect on the University or expose him or his activity to criticism.

4. He must pay a reasonable fee to the University for the use of its facilities.

Effect upon the Public of Professional Practice by Engineering Instructors

The engineers who criticize the practice under consideration, ignore the fact that no engineering instructor would have opportunities to practice for fees if the public did not wish to have him do so. Not only is an engineering instructor's ability guaranteed by the position he occupies, but it is generally understood that a man of questionable integrity would not be retained by any good college. It is hardly surprising, therefore, to find that citizens *demand* that instructors in engineering help them solve their problems. People who do not frequently have occasion to seek engineering service and advice do not know to whom to turn for help of this kind. They are aware of only one place where they can be sure to obtain reliable help, and that is a college faculty. Since college faculties contain many of the foremost recognized authorities on engineering subjects, men whose long training and research work may be an invaluable aid to the public if they are permitted to practice in their spare time, it would seem not only wrong but very unwise to forbid them to extend the service desired. Even big concerns with ample resources which can afford to hire any engineer to help them solve their problems, often are not satisfied unless they can employ a recognized authority who is a member of the faculty of some engineering college. Should they be forbidden the privilege of securing the help they need?

The number of people, who are served by engineering instructors and who would doubtless resent any regulation which would prevent the instructors from helping them, is probably fully as great as the number of engineers who would secure additional commissions if the competition of the instructors were eliminated.

Furthermore, if the privilege of employing engineering instructors is denied to our citizens, many of the latter will probably employ incompetent or dishonest pseudo-engineers because generally unable to distinguish between the claims of worthy and unworthy men.

It should also be remembered that, in some states, there exist no commercial testing laboratories and not enough work is available to support such laboratories. In Arizona, the University possesses the only laboratories in which commercial tests of fuels, motors, meters, generators, engines, ore, structural materials, etc., can be made. The University cannot afford to employ men who would devote their entire time to making such tests, commercially, in these laboratories, since months may pass with no demands for tests, and then several tests may be demanded in a few days. If the instructors are not permitted to make the tests in their spare

time, these tests and the money paid for them must go out of the state.

Summary

In this article the writer believes that he has shown that

1. The practice of permitting engineering instructors to accept professional commissions for fees during their spare time is almost universally permitted in this country, and is encouraged in the majority of engineering colleges.

2. The financial effect of this competition upon an individual non-teaching engineer is inconsequential instead of serious as many practicing engineers believe it to be.

3. There is nothing wrong in the practice since it is rather generally recognized that people have a right to use their spare time as they please, and similar profit-earning activities by instructors in other lines are not criticized.

4. It is perfectly fair for instructors to compete with their graduates in this way since, even when the practice is followed, the income of an engineering instructor is, in normal times, on an average, only about three quarters of the income of one of the graduates who is not teaching and has been out of college as long as he has.

5. The average engineer contributes such an utterly inconsequential sum in taxes toward the payment of engineering professors' salaries that he has no right to dictate what they shall or shall not do.

6. The splendid results obtained by engineering education in this country are largely due to the fact that the instructors are both teachers and practicing engineers. They are both theorists and practical men who can and do compete successfully with non-teaching engineers.

7. Good engineers are rarely satisfied to do nothing but teach, and the quality of engineering instruction would be lowered deplorably if the practice under consideration were forbidden.

8. The practice provides the best possible incentive for the engineering instructor to keep up to date, furnishes him with much valuable illustrative material, and gives him welcome and beneficial changes in routine duties; it undoubtedly makes of him a much better teacher than he could otherwise be.

9. The practice should be safeguarded by certain reasonable regulations.

10. The practice makes it possible for engineering instructors to render a valuable service to the public which the latter has a right to and does demand, and the number of persons thus aided is probably as large as the number of engineers who are adversely affected by the competition of the instructors.

PSYCHOLOGICAL PRINCIPLES APPLIED TO THE LEARNING PROCESS IN ENGINEERING SUBJECTS *

By B. P. REINSCH

Professor of Mathematics, Southern College, Lakeland, Fla.

Introduction

Psychology deals with the human mind. It aims to discover just how the mind works under various conditions. And so psychology has established laws and principles which govern in the learning process. All theories of education must be founded on the principles of psychology because we are training minds. In our teaching, we must conform ourselves to the peculiarities and limitations of the mind, we must adjust our methods to the natural ways in which the mind works.

Psychology gives us suggestions on how we can make our teaching more effective, on how we can best achieve certain desirable results. In this paper we shall list some of the elementary principles of psychology and attempt to show exactly how they apply in particular situations. It is true that some teachers employ many of these principles and methods unconsciously. For consistently good results, however, teachers must make a conscious effort, yes a determined and well-planned effort, to invent and adopt methods in harmony with the laws of learning. As a basis for our discussion let us first formulate some of the objectives or aims in our teaching.

Important Aims in Teaching Engineering Subjects

In deciding on particular methods of teaching, we must necessarily make clear in our own minds exactly what it is that we wish to accomplish. We must have clear-cut and well-defined ideas concerning our aims. In what specific ways do we expect to train the student's mind? Exactly what abilities should be developed? Some important aims are the following:

1. *To help the student in the acquisition of knowledge.* We must help him in the learning of a set of facts and principles.
2. *To help the student to understand thoroughly all fundamental principles,* that is, all fundamental principles of mathematics, physics, chemistry, mechanics, strength of materials,

* Presented at the meeting of the Texas Section, S. P. E. E., University of Texas, April 21–22, 1933.

hydraulics, thermodynamics, etc. It is evident that a *knowledge* alone of principles is of little value unless accompanied by a thorough *understanding,* so that these principles can be correctly applied.

3. *To develop the student's ability to use all fundamental principles as tools—to apply them.* The student should not merely be a mechanical manipulator or imitator. He should develop his ability to apply the principles of mathematics, physics, mechanics, etc., to new situations. A student may well have a thorough knowledge and understanding of principles, and yet not be able to use them in the applications.
4. *To develop the student's ability to think and reason carefully and correctly,* systematically to approach and analyze new problems. He should draw *correct* conclusions from given assumptions or given data—not "jump" to conclusions.
5. *To train the student to do independent thinking.* He should not follow slavishly the thoughts and developments of teacher or author. He should often carry out demonstrations or investigations according to his own ideas, on his own initiative. He should be given plenty of opportunity to develop good judgment.
6. *To help the student appreciate the beauties and wonders*—in mathematics, physics, electrical principles, machine design, etc. Occasional reflections or comments on the beautiful, the artistic, or the miraculous aspects of subject matter, are sure to generate enthusiasm and interest. Many minds welcome this as a relief from monotonous emphasis of the utilitarian.
7. *To help the student acquire the habit of alert and voluntary attention.* The teacher should have innumerable tricks at his disposal to encourage this habit.
8. *To help the student acquire the habit of a questioning attitude.* He is never to take things for granted. He should not accept as gospel truth all statements by author or teacher, but should be required to verify or check them. He should on his own initiative raise questions or state new problems. For example, he will find it a very fruitful and instructive practice to change slightly the conditions in a given problem and to question himself as to the consequent changes in the results. He might ask himself "Under what conditions does the problem have a solution?"
9. *To help the student acquire the habit of searching persistently for relations, logical connections, and applications.* As will be shown later, this habit is very important for effective learning.

10. *To help the student acquire the habit of consciousness of principles.* A student who works mechanically is sure to make many errors. He can keep from making these errors by justifying every step he takes, by recalling carefully every principle used.
11. *To help the student develop the habit of self-activity.* This will develop initiative. He should not always be dependent on explicit instructions by the teacher. He should be encouraged to do things other than those expressly assigned. The student learns most from the things he has worked out by himself. It will be noticed that, in the foregoing statements of aims, emphasis has continually been put on *student activity.* The teacher is merely to be a director or guide for the student's activities.

Psychological Principles of Learning

Below is a list of some of the elementary laws of psychology which govern in the learning process. It is to be remembered that these laws are similar to physical laws in that they have been established by experience, and are now universally accepted as being true.

Thought and Memory

A. General Laws of Association govern all of our thinking and recall (memory). All objects of thought are connected or associated with each other in various ways in our mind. We, therefore, recall objects and principles because of their relations to other objects or principles. There is no such thing as an isolated thought. The very idea of "thought" involves making associations, or connections, or comparisons. Some of the types of connections or associations are:

Association by Similarity.—For illustration, we meet a man who resembles an intimate friend of ours. Then every time we meet that man again we find ourselves thinking of our friend.

We recall the formula $1 + \operatorname{ctn}^2 x = \csc^2 x$ from the formula $1 + \tan^2 x = \sec^2 x$ because of their similarity. There is only a slight difference; namely, the functions in the one are replaced by the corresponding co-functions in the other.

It is because of this same association by similarity that an elementary student makes the following error of cancelling, $\frac{3 + \text{m}}{\text{m}}$, which doesn't seem so very different from the case, $\frac{(3 + \text{m})\text{m}}{\text{m}}$ where cancellation is permitted. Here the student has failed to

make the *Association by Contrast, i.e.,* one can cancel factors, but one can't cancel terms.

In similar fashion, a student, knowing that the centroid of any triangle is at a distance from the base equal to one-third the altitude of the triangle, erroneously concludes that the centroid of a circular cone is also a distance from the base equal to one-third the altitude of the cone. He has seen a slight similarity but has failed to make the contrast that a circular cone is really a collection of triangular plates with varying altitudes.

Association by Cause and Effect.—If driving fast in a car we suddenly find ourselves on a slippery asphalt pavement, we immediately think of "wrecked car" or "possible death." It would be too bad for us if our minds didn't make that association at once.

When a student makes an isometric or a perspective sketch of a right circular cone, he must be careful to draw the circular base and circular sections as true ellipses to give the effect of reality. Why? Projections of circles on inclined planes are ellipses. This is Cause and Effect.

Association by Whole and Part. This is illustrated in physics by the complete description of a substance involving its three distinct forms—solid, liquid, and vapor. Whole and part. When we think of an engine, we automatically think of its parts: piston, fly wheel, cams, etc.

Association by Substance and Property. In mechanics a force system in which the number of unknown quantities is greater than the number of available equilibrium equations is associated with the property of being statically indeterminate.

B. Thorough understanding of and usefulness of a principle increase as more and more associations are made. The degree of usefulness of a principle depends on the number and variety of applications (associations) that we have in mind. A fact or principle (say from mathematics, physics, or mechanics) which is not attached to an application is worse than useless. For example, a student doesn't fully understand a "linear equation" until he has used it repeatedly in the solution of practical problems in various fields. Why? More associations have been made.

It is important to note that if in teaching certain principles we do not give sufficient immediate practice in applications, then the student will not be able to recall or use these principles when needed later. This is well illustrated in the first part of our course in mechanics. Here, statics has at basis only the two or three equilibrium equations—very simple principles. Yet we know that a student does not fully understand these until after many lessons on their applications to particular situations. Only after much practice will he finally be able to use these principles correctly in

new situations. Their usefulness increases with the number of new associations he has made. And with these new associations and applications, his true understanding of principles increases. Knowledge and true understanding is a "growing affair." We should apply these facts of learning to everything else that we teach.

C. Interesting things are remembered most easily. Subject matter must be made interesting and appealing to the student. His curiosity should be aroused. He learns most easily those things in which he finds pleasure.

D. Extremely vivid things or experiences are easily remembered. Forceful special examples and illustrations, good freehand blackboard sketches, make lasting impressions.

E. Easy to recall things that happened recently. This principle shows the necessity for frequent reviews.

F. Easy to recall familiar things—things thoroughly understood. The best way to learn or memorize principles (say, for example, of mathematics or physics) is to understand them or know how to derive them. After a thing is thoroughly understood the memorization will take care of itself.

G. Memory is aided by frequent reviews. New applications produce new associations. Memory depends entirely on the association of ideas, the idea in mind recalling the ideas to which it has been linked by some past association. Each review will establish new associations and therefore improve the ability to recall. If in reviewing we apply principles to slightly new situations (new applications), then these old principles will be more thoroughly understood; and because more thoroughly understood they will be more easily recalled.

It is important to note in this connection that the lesson, that is studied but once, is learned only to be forgotten. That which is repeatedly reviewed is intricately woven into the fabric of our thoughts and becomes a part of our permanent knowledge. We shouldn't forget that a student's true knowledge and ability is measured by what he *remembers permanently* and not by what he has once learned and recited. One fact well remembered is worth more than 100 facts which are forgotten.

H. Appeal to both the visual and the auditory memory. It is very helpful to give graphical and physical illustrations simultaneously with the algebraic, analytic, or abstract, thereby appealing to both types of memory. Many students have strong visual memories, again others can think only in terms of the concrete.

Habits and Abilities

I. To develop a habit, one act is not sufficient—constant repetitions are needed. If the student is, for example, to acquire the habit of always checking his work, it is not sufficient to tell him to do so once or twice. He must be required to do it always. Then too, the teacher himself should do it in his own board work in front of the students. The above teaching aims numbered 7 to 11 inclusive were intentionally stated as the development of certain desirable *habits*. This is to call attention to the necessity for constant practice and constant repetitions.

J. To develop certain specific abilities, we must constantly practice those very abilities. A student in descriptive geometry, who possesses a general ability to draw the projections of points and lines, will not automatically possess the specific ability to draw the projections of two intersecting plane-faced solids. No, he needs additional practice in this specific problem.

K. Mere practice does not make perfect. The mere repetition of an activity does not improve it. Improvement depends on beneficial variations. This is nicely illustrated by the quadratic equation in algebra. In the sets of problems on the solution of quadratic equations many texts give twenty or more equations all in exactly the same form, $2x^2 - 3x + 5 = 0$, all monotonously alike. Here variation is needed. Many students who can easily solve the former equation, will encounter difficulties if the equation is written in the following forms: $3w^2 = 3 - 5w$, $3y + 1 - 2y^2 = 0$, $6x^2 - 7 = 0$, $4x(1 - x) = 6$, $.09t^2 - 3.2t = 4$.

Particular Methods and Practices in Teaching Engineering Subjects

We shall now list some particular methods of procedure which are justified by the foregoing Aims and are in harmony with the Laws of Learning. Immediately after each of the following statements (*a*), (*b*), (*c*), etc., we shall give the numbers of the particular Teaching Aims (1, 2, 3, etc.) and the letters (*A*, *B*, *C*, etc.) designating the particular Principles of Learning listed above which apply to those statements. The reader can then easily determine the exact reasons why these particular practices are justified or desirable.

(*a*) *Explain unknown facts in terms of the known facts.* (1, 2, 6, 9, *A*, *B*, *F*.) Tie up a fact to be remembered with a group of known facts with which it is in some way related. It is easier to remember related facts, for the mention of one will naturally recall the others. Scrutinize each new fact and search for relations or contacts with old facts. Reduce the number of principles to a

minimum and make others depend on these. This effects an organization of subject matter. Illustrations: the laws of radicals should be explained not as new laws but rather as the old familiar laws of exponents. Similarly the laws of logarithms are nothing but the exponent laws written in a new form. The identity, $\tan^2 x + 1 = \sec^2 x$, is really the same as the identity, $\sin^2 x + \cos^2 x = 1$, with each term divided by $\cos^2 x$. If the student is familiar with the graph of $y = \cos x$, he can easily sketch the graph of $y = \sec x$, because its ordinates are merely the reciprocals of the ordinates of $y = \cos x$. Any curvilinear motion may be regarded as a pair of straight line motions.

(*b*) ***Make pictures, sketches, or graphs wherever possible to illustrate.*** (2, 4, ***A, B, D, H.***) Always demand of students that they themselves draw figures, graphs, or rough sketches in connection with all problems. In attacking problems students will answer most of their own questions if they make careful sketches. An idea is seldom so abstract that it can't be illustrated by some sketch or physical analogue.

Illustrations: The physical significance of "direct variation" and "inverse variation" is easily brought home to the student by sketching the family of straight lines, $y = kx$, and the family of hyperbolas $y = K/x$. The meaning of the evaluation of indeterminate forms such as

$$\lim_{x \to 0} \frac{\sin x}{x} = 1, \qquad \lim_{x \to \infty} \left(1 + \frac{1}{x}\right)^x = e = 2.718 \cdots,$$

is made clear by drawing the graphs of the curves $y = \sin x/x$ and $y = (1 + x^{-1})^x$ and by seeing what happens as $x \to 0$ in the first (merely a tiny hole in the graph at $x = 0$ and $y = 1$), and as $x \to \infty$ in the second (a horizontal asymptote at $y = e = 2.718. \ldots$)

Note: For reasons of simplicity, clearness, and brevity most of the following illustrations are selected from elementary mathematics. The reader will be able to recall or construct similar illustrations in all engineering subjects. In certain fields, the teacher might well do some real pioneering and create new methods of teaching and design new methods of presenting subject matter because the traditional methods are often notoriously inefficient when studied in the light of the laws of learning.

(*c*) ***Fundamental facts, principles, or methods should be recalled at frequent intervals and used in new connections.*** (2, 3, 9, ***A, B, F, G.***) As already indicated, this enriches the student's understanding of principles, and aids his memory materially. The ability to solve a quadratic equation quickly under any condition

is so fundamental and important that students should be given every possible opportunity to work with it. Bring it in again when solving equations of higher degree like $x^3 - 8 = (x-2)(x^2+2x+4) = 0$; and again as exponential equations, $e^x + e^{-x} = 4$ or $e^{2x} - 4e^x + 1 = 0$, $e^x = ?$; again when studying trigonometric equations, $\sin^2 x - \sin x = 3$. In analytics bring in the quadratic again in finding intercepts of the curve $2y = x^2 - 3x + 7$; in identifying the curve or plotting the factorable locus $x^2 - xy - 2y^2 + 3y - 1 = 0$ from which $y = 1/4(3 - x \pm \sqrt{9x^2 - 6x + 1}) = 1 - x$ or $1/2(x+1)$; in finding asymptotes and discussing extent when equations like $y = x/(x^2 - 3)$ or $(y-1)^2\ x - y = 0$ have to be solved both for x and for y. Again in calculus bring in the quadratic equation wherever there is an opportunity. After such repeated applications a student is sure to know his quadratic. A similar plan should be followed in teaching other fundamental and important principles.

(*d*) *Often give extraneous, unnecessary, or inconsistent data.* (2, 3, 4, 5, 7, 8, 10.) The student should have much practice in selecting the data required for certain problems, for this he must be able to do later in life. Give unnecessary data wherever possible, and occasionally inconsistent data. This encourages alertness and careful analysis. The mechanical manipulator will be exposed and penalized. Text books are very weak on this point.

Illustrations: Ask for the area of a geometrical figure in which more than the necessary dimensions are given. Require the diameter of sphere for which both the weight and the volume are given. Find the equation of a straight line through the three points $(-2, -3)$, $(0, 1)$ and $(2, 5)$, which is possible only if these points are collinear.

(*e*) *Occasionally give impossible problems or problems that have no solution.* (2, 3, 4, 5, 7, 8, 10, *A, B, F.*) This encourages alertness and careful thinking. It is often just as valuable to know what can't be done as it is to know what can be done. Textbooks are deplorably weak on this point.

Illustrations: Ask for the area of a quadrilateral, given the lengths of the four sides only. Ask for the factors of $x^2 + 4 = (x + 2i)(x - 2i)$ and bring out the idea of factorability in certain domains. Ask for the solution of the equation $x^2 - 1 = x(x+1) - (x-1)$ which happens to have no solution; or ask for the solution of $x^2 - 4 = x(x+2) - 2(x+2)$ for which every number is a solution. Ask for the solution of $2\cos x + 3 = 0$ from which $\cos x = -3/2$, hence, impossible, because the cosine is never numerically greater than unity.

(*f*) *Teach all the different types of notation. Use them all frequently.* (1, 2, 3, *A, I, J.*) For example, all the different sym-

bols for ordinary and partial derivatives. Both notations for inverse functions: $A = \text{arc tan } 2 = \tan^{-1} 2$.

(*g*) *Change the set-up and letters in proofs and demonstrations.* (2, 3, 10, *F, J.*) If the text gives a certain demonstration with an acute angle, then require the students to work it out by using an obtuse angle. Change the conditions or assumptions in some way. Reverse figures, or turn them upside down. In analytics ask for derivations with the given points first in one quadrant and then in others. Also make students independent of notation or particular letters. If the text uses the letters *P, Q,* and *R* on a figure then have student use others like *B, C,* and *K.* Of course, all standard symbols like "*I*" for moment of inertia or "*v*" for velocity should never be changed.

(*h*) *Create interest by humanizing the subject.* (1, 6, *A, B, C, F.*) Bring in the human element, little bits of history, illustrative personal anecdotes, or special applications wherever they enter in a natural way. These sidelights or references should be very carefully used so as to be of maximum value—never permit time to be wasted.

(*i*) *Give students practice in setting up problems.* (2, 3, 4, 5, 7, 8, 9, 10, 11, *B, D, J, K.*) State problems so that students are required to determine for themselves what particular methods, formulas, or relations are needed. This is required in all applications in daily life. Illustrations: In asking for the computation by integration of the centroid of any right circular cone do not give any equations or any coördinate axes; let the student determine these. Often give problems that can be solved by two or more different methods and give special credit to those who offer the simplest and best solutions.

(*j*) *Frequently confront the student with unusual situations and problems.* (2, 3, 4, 5, 7, 8, 10, *A, B, C, D.*) Illustrations: Ask for the equation of a parabola with vertical axis passing through the points (0, 0) and (6, 0). This is unusual because there are many parabolas satisfying the given conditions, and the student will have to do some thinking. After studying parabolas and circles ask students to sketch the graphs of $y^2 = 4x^2$ and $(x-3)^4 + (y-2)^4 = 4$. Many will erroneously draw a parabola and a circle respectively, and consequently show that they need to learn much more about these standard curves.

(*k*) *Teach students self-reliance by requiring preliminary estimates, checks, alternate methods of attack, tests of reasonableness of result.* (3, 4, 5, 8, 11, *A, B, D, F, J, K.*) Students should not be slaves to an answer book. It is often a good thing to have incorrect answers in a text. Rough estimates and checks can often be made graphically. Often general formulas or relations can be

checked by the homogeneity test—all terms must be of the same dimensions. For example, the formula for a certain volume, $V = 3\pi h(R^2 - r^2) + \pi h^2$ is obviously incorrect because the last term is of dimension two instead of dimension three.

(*l*) *Give students opportunities to make errors.* (2, 3, 4, 7, 8, 10, *A, D, I, J.*) This is very important in testing the student's true understanding of principles. A good plan is to keep a list of errors commonly made and then design problems containing temptations to make these errors. Students need much practice in performing certain troublesome operations correctly without making errors.

(*m*) *Don't teach simplest illustrations of principles only.* (1, 2, 3, *A, B, F, J.*) Always bring in a few more complex problems. In late years many textbooks have simplified all problems and illustrations to the point of making them unnatural. Such treatments are often harmful in preventing students from getting a complete and thorough understanding of principles. Illustrations: All problems on linear and quadratic equations are often too simple. In logarithmic computations be sure to evaluate several decimals raised to decimal powers like $(0.438)^{0.203}$ for these are needed in thermodynamics. Many students can easily solve the equation $2^x = 30$, but are helpless when trying to solve $(.023)^x = 60$. In physics, usually only that type of straight line motion for which the acceleration is constant is studied, and hence, students get the erroneous notion that average speed is always equal to one-half the sum of the initial and final speeds. Also most physics texts treat only a very special case of general curvilinear motion, namely, uniform motion in a circle, so that students get an entirely wrong conception of total acceleration and its components, the normal and tangential accelerations.

(*n*) *Train the speed of perception by appropriate drills.* (3, 7, *E, G, J, K.*) Give plenty of practice in the speedy recognition of types or relations, in the determination of proper methods.

(*o*) *Students learn by doing and not by being told.* (2, 3, 4, 5, 7, 9, 10, 11, *A, B, D, J.*) Because of this, students must necessarily be required actually to work out and hand in for correction many problems. The teacher must continually check up to see if the student really does the required home work. Instead of the teacher working out a problem on the board have all the students work it out with the help of the teacher.

(*p*) *Frequently give problems embodying two or more different principles—small research problems.* (2, 3, 4, 5, 7, 8, 9, 10, 11, *A, B, C, G, J, K.*) This is exactly the way in which the fundamental principles of mathematics, mechanics, etc., are to be used in all applications. Research ability is developed gradually, and should be practiced in an elementary manner as soon as possible.

For example, ask a sophomore to prove that *any* segment cut from *any* parabola has an area two-thirds that of the circumscribed parallelogram. He will first need to decide on positions of axes and equations of curves, and then use algebra, analytics, and calculus.

(*q*) *Give problems that first require certain necessary simplifications or adaptations before proceeding with the regular solution.* (3, 4, 5, 7, 8, 10, 11, *A, B, E, F, G, I, J, K.*) Illustrations: In evaluating the expression $\sec x/(\sec^2 x - \tan^2 x)$ for $x = 38°$, the student should first simplify it to $\sec x$. Before finding the derivative of $(\sin^2 x - \cos^2 x)/\sin 2x$, simplify it to $(-\operatorname{ctn} 2x)$. By means of such problems the student is made to realize that he can save much work and time by first looking for simplifications or changes. He also learns the value of being able to recognize certain trigonometric identities at a glance.

(*r*) *Explain general principles by means of particular cases or illustrations.* (2, 9, *A, B, D, F.*) For example, demonstrate the error of $\sqrt{a^2 + b^2} = a + b$ by means of $5 = \sqrt{25} = \sqrt{9 + 16} = 3 + 4 = 7$.

(*s*) *Encourage careful and accurate thinking in various ways.* (4, 7, *I, J.*) For example, distinguish carefully between "equal to" and "approximately equal to." If certain formulas require all dimensions to be measured in feet, then give some of the data in inches.

(*t*) *Distinguish between learning verbal rules and definitions, and learning facts.* (2, 8, *B, F.*) Rules and definitions are often misused. One could teach an eight year old child to recite correctly the formula for the area of a trapezoid without his knowing what a trapezoid is; or even to give the correct definition of "function." Obviously the mere reciting of rules and definitions has no connection with the knowledge of or understanding of facts. A rule should be the result of a set of experiences. It should never be a substitute for experience. Learn the facts first, and then the main features or significant ideas might be summarized in a rule. Questions should always aim to test the understanding of principles rather than call for their reproduction from memory.

(*u*) *Give data with specified units and then require results in correct units.* (2, 4, *J.*) The practice of some texts, particularly in mathematics, of often giving data or dimensions as pure numbers with no definite units attached is to be condemned. Students need much practice in working with various units. For example, if the student is required to find the kinetic energy of rotation of a certain cylinder in foot-pounds, some dimensions should be given in inches, possibly the density in lbs./cu. in., and the angular velocity in revolutions per minute, say. Then the student must

change all of these to the correct units to get the result in foot-pounds.

(*v*) *Bring in decimals wherever possible and natural. Don't use integers exclusively.* (3, *J*, *K*.)

(*w*) *Frequently give short and long examinations of the correct character to compel the student to organize his material and carry it in mind.* (1, 4, 9, *B*, *G*, *J*.) The making and giving of proper examinations and tests is a science, which requires constant study.

(*x*) *Comprehensive examinations covering several subjects, or two or more years of work, are very desirable.* (1, 2, 3, 4, 10, 11, *A*, *B*, *G*, *I*, *J*, *K*.) These can be made very helpful in requiring students to organize and find relationships between related subjects. They combat the tendency to permit a subject to drop out of mind as soon as it is no longer required for a time. Notice the merits of the comprehensive examinations on two years of work as given in the University of Chicago's new plan.

(*y*) *Continually establish relationships and contacts between the subject you are teaching and related subjects.* (2, 3, 9, *A*, *B*, *G*, *J*.) We are not permitting our laws of learning to help us when we treat all of our subjects too strictly in separate compartments. A teacher will need continually to study related subjects to enable him to make the desirable contacts. Yes, the teachers of junior and senior classes must *continue* the work started in the freshman and sophomore classes, and must also teach a little more mathematics, physics, etc. Why? First, because these advanced courses are nothing but applications of the fundamental principles, and secondly, because all knowledge is a "growing affair." A physics or surveying teacher should, for example, correct gross errors that students make in English. Along this line, the so-called "problem courses" for freshmen or sophomores are a big step in the right direction. Our engineering curricula can all be improved by more of this coördination between subjects.

(*z*) *Measure the achievements of a student not by grades made on the old essay-type examination, but rather design new type tests to determine their true understanding of principles.* (2, 3, 4, 5, 10, *A*, *B*, *J*.) Examinations should very rarely merely call for things the student has memorized.

Conclusion

May this brief outline of suggested methods of putting our teaching on a good psychological basis urge all of us to do some real research in effective methods of teaching.

We teachers of engineering subjects have wonderful opportunities to train the student's mind, to develop his reasoning powers.

Are we doing this as effectively as we should? Doesn't a thorough study of psychology and the learning process show us that we are far from being as scientific in our teaching methods as we are in other things?

Much of the current criticism by industry and by the general public of the results of our college work is probably due to the lack of emphasis on the part of teachers on aims numbered 2 to 11 as I have listed them. Too many concentrate 95 per cent of their attention on aim number 1, the acquisition of facts and knowledge, and fallaciously assume that all the other aims will take care of themselves.

Each time a teacher designs his "lesson plan" or constructs a "test," he should recall all of these psychological principles and attempt to make the best possible use of them. In applying these principles systematically, a teacher will constantly discover how he can improve his methods. The course he teaches will be ever changing, it will be dynamic, ever fresh and attractive.

No teacher can lay claim to being good unless he regularly spends almost as much time as the student himself in preparing for class. Yes, teaching is a man's-size job. You say it's an art, and teachers are born, and not made? Yes, possibly. But above all, teaching is a science.

EFFICIENT PREPARATION OF ENGINEERING LABORATORY REPORTS *

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The solutions of the problems this subject brings up probably will provoke considerable disagreement among engineering teachers. However, if laboratory students were consulted, general agreement would probably be found on two points: first, that the time required for laboratory reports is far too great for the academic credit which results and, second, that the time required is often too much for the good that results. Very possibly those opinions will change as the student grows older, and certainly the matter of academic credit is one which cannot be discussed here; but I think we can easily agree that any means of decreasing the time consumed by our laboratory instruction should be investigated. Even if we should not want to return the time saved to the student, many of us would be glad to apply it on other courses in our crowded four year curriculum.

The student's time is consumed in two ways: securing the data and writing the report; and legitimate attempts at time saving can be made in both fields.

In collecting data, the best provision for efficiency is knowledge of what must be done. As a minimum requirement, the student leader of the group should be prepared; and one incentive in that direction consists in requiring him to present at the beginning of the laboratory period some evidence of that fact. This evidence can take the form of data sheets ready for use, with proper column headings, plus a written assignment of duties for each member of his group. I have seen printed data sheets in use, these having been prepared for each experiment and furnished by the faculty. This practice seems to me a very poor one, since it discourages advance preparation and diminishes the need for thought and decision. Though it may increase the number of experiments performed, what the student gains by it in ground covered he loses in seriously lessened opportunity for the development of initiative. If such a system be used at all, it should be limited to a very few experiments early in the course.

In a similar way, the selection and preparation of laboratory

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equipment in advance may be carried too far by the faculty. The arrangement and connection of apparatus ought to be made easy but not too easy; the student should have proper facilities for his work, but these should not be provided to the extent of eliminating practice in corrrect and neat arrangement of test equipment. In the same way, the selection of apparatus needed and the preparation of a tool-room requisition should be left up to students if that requirement does not take too much time or experience. Sometimes this selection really will take considerable experience, sometimes not. I believe that in electrical engineering laboratories instrument selection can be required of students in advance but that in mechanical engineering laboratories where the apparatus is more permanent and where the attachment of instruments depends more on the local arrangements, such as piping, the apparatus list often should be given the student in advance and in considerable detail.

While a well-prepared laboratory and a well-prepared student leader will probably turn out a fair experiment, of course a better one will result if all the group has had sufficient preparation for a given experiment. To secure this end, several methods are available. One of our laboratories uses a brief lecture given a few days preceding the laboratory period. In this lecture is stated the governing theory and the special precautions required by local laboratory arrangements. The student's lecture notes are supposed to give him all necessary advance information. This plan has the advantage that the student's attention to such matters is insured, at least to some extent.

Another common practice used in two of our laboratories is to give the theory in assigned references which are to be read before entering the laboratory and to describe local procedure and equipment in mimeographed instructions. This method has the advantage of maintaining a uniform standard in a given experiment from year to year, and it is easier on the instructor than the lecture method. Having one laboratory issue written instructions and another laboratory use oral instructions probably gives the student useful practice in following both types of orders.

Another possibility (which can be added to the preceding suggestions if desired) requires from the student a written pre-report which later becomes part of the final report. It may contain a statement of the theory, the data sheets prepared ready for use, and a requisition for equipment. When approved by the instructor, it acts as a ticket of admission to the laboratory. Its contents should not duplicate the materials required in the report itself.

A threat of quizzes covering laboratory references and held just prior to the start of an experiment is another possible means for stimulating advanced preparation but this threat does not seem

to be taken very seriously, in spite of the fact that the quizzes are actually given occasionally.

As regards the preparation of the report itself, my first suggestion is that of standardizing on details as far as possible in all engineering laboratories in a given school. This means standardizing on the form of laboratory report and on general laboratory practices. Probably the same general form and practices cannot be followed in both pure science and engineering laboratories, but usually there is enough similarity in work and enough coöperation among the engineering laboratories so that the students going from a civil laboratory to a mechanical laboratory need not remember a very different set of rules or write up a very different form of report. This similarity is especially helpful to the student who is just starting into engineering laboratories, and it is from such students that the loudest criticisms of laboratory work are heard. The details of procedure within different laboratories will vary, of course—water and steam are handled differently from electricity—but the general laboratory rules and especially the form of report can be made fairly uniform if the faculty will take the trouble to make them so. Our method is to issue to each student entering an engineering laboratory a mimeographed set of rules holding for all laboratories and all reports. Added to the general rules is a sheet containing rules peculiar to that special laboratory. Usually these special rules relate chiefly to machinery or accident risks peculiar to that special department and have no relation to the form of the reports.

Another opportunity for saving time appears in minimizing mechanical copying. Reporting data directly to a student recorder who uses carbon paper liberally enough to give each student in his group an original set of data is a practice which saves time and minimizes wasted labor due to errors in copying. Moreover, the recorder's classmates put pressure on him for neatness in ways the instructor cannot approximate. Even the use of the mimeograph to issue lengthy original observed data—as in a long boiler test—may be wise. The work of recording ought, of course, to rotate in a group.

If we apply such labor-saving expedients a little further, we meet the question of duplicating curves. Should each man plot them individually, or may one set be plotted by the leader on tracing paper, with the other men in the group using blueprints taken from this tracing? Widely different answers to this question will be found. One teacher will argue that students entering the Junior year ought to need very little instruction or practice in plotting; but this is certainly not always true. And if one makes the concession of allowing the blueprinting of curves, how about

wiring diagrams and piping sketches and drawings of apparatus? Or to go even further, why not let the students take turns writing up the whole experiment, making carbon copies or blueprint copies for the other members of the group, a practice I believe is followed in some schools? Always the answer to questions of this sort depends on the educational value of the activity eliminated.

Some place in between the two extremes of individual all-hand-work and of complete preparation by one student lies, I think, an optimum condition requiring a minimum of time and a necessary requirement of personal, independent effort from the student. Just where this optimum condition lies will, of course, be hard to say. Personally, I think that in every case the diagram of connections or the sketch of equipment set-up ought to be made personally by each student and that conclusions and answers to questions should also be written individually. Certain other parts we can probably allow to be duplicated mechanically after the student has had a certain amount of individual practice—say in the second semester or in the Senior year.

A problem similar to that of mechanical duplication is the quality of drafting and lettering required. Lettered title sheets, titles on curves, neatly lettered data sheets—all these require a good deal of time, and frequently they can be prepared very neatly on the typewriter. Should hand work be insisted upon in these cases? Here again I feel that when the student has proved that he can do a good job manually, he should be allowed to use mechanical aids if he wishes, just as we allow the use of slide rules and departmental adding machines in computations. Our own practice is this: during the Junior year, engineering laboratory reports must have lettered title sheets and the like. This is required because most Junior students are not in design courses and do not perform much drafting work. Also, they are not turning in quite so many reports as the Seniors. But in the Senior year, typewriting is allowed and is preferred by many students. In fact, we find today a certain number of students who are so accustomed to the typewriter that they prefer even to take their original data in the laboratory on portable machines.

In addition to the problem of efficient methods of report preparation, the laboratory instructor must consider the form of presentation of the material. Here he may find a conflict between the arrangement best suited to commercial and professional needs and the arrangement apparently best suited to the educational purpose of the school report. For some years, we used the latter type —the type I suspect most of us were taught to write at our alma maters. It took up in this order: apparatus, object, theory, pro-

cedure, computations, and finally, at the very end, conclusions or results, together with curves.

This order is an entirely logical one to follow in preparing the data, but it is not the most satisfactory one for the busy executive who wishes to absorb the essentials of a report as quickly as possible. This man wants to reach the heart of the report at once, and perhaps he reads no further. Such a report, with the results stated in the first paragraph, resembles very strongly the reprints of technical papers as they now appear in engineering society journals—that is, such papers state the results and conclusions first, in condensed form; then they bring up the details of the test later, where the reader may or may not read them, as his interest suggests. If such a form be desirable in commercial reports, is it wise to teach in the schools a form which must be unlearned later?

Several years ago, we decided to see if our students could not write reports closer to the commercial standard and at the same time meet the educational requirements of the college laboratory report. The necessary changes were rather simple; it was almost entirely a matter of rearrangement of old report material. To-day, all of our engineering laboratory reports are made up of two parts: the report proper and an appendix. The report proper contains a title sheet, a statement of the purposes of the experiment and a brief summary of conclusions reached, curved sheets, a sketch of the apparatus employed, a general discussion of peculiarities of equipment or peculiarities of test method, a discussion of difficulties experienced, tables of condensed data (that is, averaged data per run), and finally a discussion of curves, accuracy of test, and normality of test results. The appendix contains all detailed data, sample calculations, numbers of instruments, the mimeographed instruction sheets, and similar information. Such a report seems to be quite as easy to write as the older form, is as easy to grade or easier, and certainly has a much closer resemblance to the commercial article. We have even gone a little further, and occasionally for elaborate tests we require that the report proper be in the form of a letter addressed to the maker of the equipment, telling what the test crew think of his product.

This semi-commercial form of report is of course best suited to a test of a commercial machine or a commercial material. It has no advantages in an experiment whose purpose is to learn the operation of a particular instrument or machine—an experiment for which the report is almost all description and the results pretty meagre. But most engineering laboratory reports do cover the performance of a specific machine or material; and we feel that when the recent graduate is called upon to write his first real commercial report, he will follow his old laboratory form and will turn

out a more attractive product if he uses the new arrangement rather than the old academic type.

I have emphasized only those parts of the laboratory report problem in which I thought we might possibly make a constructive suggestion not generally adopted, those points being two: the desirability of a fairly standardized laboratory report for all engineering departments, and the desirability of a form of report resembling the commercial engineering report or engineering magazine article. I hope that unknown to us some of you have developed still better practices leading to the improvement of laboratory work and that you will share your improvements with us.

ELEMENTARY WORK IN MANUFACTURING PROCESSES

By HUBER O. CROFT

Head of Department of Mechanical Engineering, University of Iowa

The majority of engineering colleges offer required work in the use and application of machine tools and other manufacturing equipment. Such courses are usually required for all those taking mechanical, chemical, and electrical engineering in the under-class years and may be followed by advanced work in the upper-class years in manufacturing processes, factory management, time and motion study, and other specialized industrial engineering courses.

The present discussion has to do only with the elementary work preceding the advanced work in manufacturing processes and industrial engineering and which may be taken by all engineers irrespective of their selected, specialized field.

The objectives of giving work in manufacturing processes should be to inform the student as completely as possible concerning (*a*) the applications of machine tools and other production equipment; (*b*) the engineering uses of materials employed in manufacturing; and (*c*) the intimate relations existing between design and production.

The principal difficulty in courses of this type from an educational view point, is to keep abreast of industry in the methods actually used due to the rapid advances made in production machines and methods.

It is the personal opinion of the writer that such courses should not attempt to instill operative and manual skill in the use of machine tools, but rather to demonstrate the purposes and possibilities of machines and processes in industry.

With this end in view, then, a "laboratory method" of instruction can be employed, involving the performance of an experiment, or the recording of observations of a process, designed to stress the pertinent facts of engineering value. A written report would then be made in much the same way that a test on a steam engine is now conducted in most steam power laboratories, except that there might not be a recording of numerical data.

There may be three distinct types of "experiments" involved in this system, namely: (1) That, involving the actual operation of a machine, or process; (2) That involving the writing of a report after the examination of a group of display boards, a machine

demonstration, or a moving picture; (3) That involving the writing of a report on a particular process after the extensive study of technical literature guided by a bibliography furnished the student.*

The Manufacturing Laboratories at the University of Iowa are now rearranging their courses to follow the general principles proposed in the preceding paragraphs. These laboratories comprise the following divisions: (*a*) machine tool; (*b*) metal technics; (*c*) casting; (*d*) wood products.

The student's time is prorated in the above divisions approximately as follows: 30 per cent in the machine tool division; 30 per cent in the metal technics division; 20 per cent in the casting division; and 20 per cent in the wood products division.

Some of the engineering information and practices which are taught in the divisions mentioned above are given the following paragraphs.

In the *Machine Tool Division*, the student is shown: The application and manufacturing possibilities of different machine tools; the elements of the use of jigs and fixtures; the standards of fits and tolerances; the applications of punch and press work; the elements of tool design; the elements of the machinability of metals; and the dependence of efficient manufacturing upon good design and the specification of the proper material.

Some of the information given the student in the *Metal Technics Division* can be summarized as follows: The application of machine and hand forging; the theory involved and the uses of gas and electric welding together with the engineering properties of the welded joint; elementary metallography from the engineer's standpoint; the heat treatment of metals; some of the elements of the flow of metals; the applications of drawing operations and die work; and some of the elementary factors involved in the design of dies.

The *Wood Products Division* gives the student information as to: The elementary biology and sources of timber; methods used in the lumbering industry; decay and shrinkage; the use, design, and making of patterns; methods of gluing and the manufacture and applications of plyboard and veneering; machining of wood; the application of wood as an engineering material to the making of boxes and crates; aeroplane parts, automobile parts, etc.; and the by-products of the wood industry, such as insulation, fuel, raw material for the chemical industry, etc.

In addition to information on the uses of wood, a few lectures and reading assignments are given on plastics and plastic molding.

The *Casting Division* gives the student an idea as to the modern

* Some of the processes suggested cannot be duplicated in the average laboratory and hence reference to literature is necessary as well as desirable.

manufacturing practices for: The design, construction, and applications of wooden, metal, and built-up patterns; hand and machine molding; the making of cores; the testing of molding and core sands; the melting and casting of ferrous and non-ferrous metals; chilling, cleaning of castings; die-casting and die-casting metals; and the differences between good and poor design from the standpoint of casting.

The laboratory schedule now being used experimentally for mechanical engineering students consists of two, 3-hour periods per week during the first semester and three, 3-hour periods per week for the second semester; both in the sophomore year. (The hours indicated herein are actual clock hours.)

The time for the above schedules is distributed approximately as follows:

Machine Tool Division:

Lectures and demonstrations	15 hrs.
Ten experiments	38 hrs.
Moving pictures	9 hrs.

Approximately 10 hrs. are given to "write up" periods and reference work.

Casting Division:

Lectures and demonstrations	11 hrs.
Pouring operations using gas furnaces and cupola	9 hrs.
Molding operations	15 hrs.
Core-making	6 hrs.
Sand testing experiments	6 hrs.
Moving pictures	7 hrs.

A term paper covering this division is required. This is done outside of the laboratory.

Metal Technics Division:

Lectures and demonstrations	24 hrs.
Experiments on heat treating welding, preparation and microscopic examination of test specimens	40 hrs.
Moving pictures	8 hrs.

No reports are written; the student records observed data and brief conclusions in his instruction book.

Wood Products Division:

Lectures and demonstrations on wood products plastics, and plastic molding	15 hrs.
Pattern design	9 hrs.
Bench work	21 hrs.

No written work is required.

The schedule for students taking chemical and electrical engineering is naturally less than noted above, but is prorated approximately in the same ratios.

It is fully realized that criticism may be made of some of the ideas suggested in this brief article; however, as long as the writer has been in the educational field, outspoken criticisms of "shop work" has been extremely popular, with very few concrete changes resulting. This records an attempt to overcome inertia in the teaching of elementary "Manufacturing Processes"; whether these changes are for the better will be determined by the future.

ENGINEERING SHOP COURSES*

By M. L. BEGEMAN

Associate Professor of Mechanical Engineering, University of Texas

In looking over the shop courses presented at the various colleges and universities of the country, one finds a wide difference of opinion as to what should be included in such a course, and how it should be taught. This difference may, in some cases, depend on the equipment that is available at the respective institutions, or possibly on the qualifications of those presenting the course. The nature of the shop course will also vary according to the aim of the curriculum in question. There are so many factors involved that we can at once see that all courses cannot be alike, yet there should be some common qualities or attributes which all shop courses should include.

The general object of a shop course should not vary much for students in a given branch of engineering. In training engineering students, our principle aim is to ground them firmly in the fundamentals of engineering, and to give them a well-rounded education. With a common aim, we can at least shape our shop courses so as to include the fundamentals involved in shop work. The purpose of a shop course as generally accepted by most schools, is to familiarize the students with: First, the various engineering materials available including their composition, method producing, properties and uses; second, the equipment used for the fabrication of these materials and, so far as possible, their operation; and third, a knowledge of the economic principles involved in production and various industrial processes. Manipulative skill is not usually included as one of the prime objects of a shop course due to the limited time available and the fact that skill in operating various pieces of equipment is not an essential qualification for an engineer. I do not intend to minimize the importance of skill, however, as it is a quality to be desired, but I believe it can best be attained in industry itself, if later the student finds that it is important to be skilled along certain lines.

I am assuming in this brief discussion, that the advisability of a shop course in certain departments of engineering is not to be questioned. Some knowledge of this subject is essential to all branches of engineering. Certain departments, particularly mechanical engineering, require considerable training along these lines, and I see no satisfactory way for these students to get such

* Presented at the 1933 Meeting of Texas section of S. P. E. E.

training other than to include it in the college curriculum. Summer work in industry is to be desired, but it can hardly replace the shop work given in schools as it lacks the necessary supervision that students should have, it is difficult to arrange and seldom is inclusive enough in its scope. Neither can we depend on having this work given in high schools as they are not equipped for the work, nor is the student ready at that time to receive the type of training he should have. The work to be prescribed properly must be coordinated with the other subjects in the engineering curriculum.

The work that should be given in a shop course should include the working of the various materials in question so that the student may become familiar with them and the equipment used in their fabrication. Wood working as applied to pattern work is usually first taken up. The student is perhaps more familiar with this type of shop work, and it is usually advisable to take it up first. The pattern work is naturally followed by work in the foundry where the student learns something of the use of the pattern in making molds and the actual casting of such metals as iron, brass, and aluminum. Following foundry work, the student next goes into the machine shop and actually operates the various production tools used in the machining of metals. Work is outlined in such a manner as to give him some operating experience on all types of equipment as well as the machining of different kinds of metals. In this way, he learns something of the possibilities of machine tools, as well as some of the properties of the metals with which he is working.

I might interpolate at this point, that the type and sequence of work as mentioned above is in line with our method of presenting the work here at the University of Texas. This work is then followed up with another course pertaining to the heat treatment and metallurgy of iron and steel, and the welding of various metals. The student here learns further regarding the properties of the ferrous metals, how they respond to various treatments, and their resulting properties. Various welding processes are studied and the students are given laboratory instruction on both oxy-acetylene and electric-arc welding. This work includes the welding of both ferrous and non-ferrous metals. We feel that the work in this course is particularly valuable to the engineer as it has been increasingly necessary in recent years for him to know more regarding the properties of metals and possibilities of the various welding processes.

All of the above work we feel is of a fundamental character, and valuable to an engineer. In many schools other courses of a specialized nature are presented, but they are usually given as elective courses. Courses of this type are usually advanced

courses of some of the above mentioned, including such subjects as jig and fixture design, tool making, research on the cutting of metals, production methods, etc. Such courses are splendid for students wishing to specialize in industrial work, but of necessity require a large and complete shop equipment and a rather large instructional staff.

There are several methods that may be followed in presenting shop work. In the first place, it may be presented in the form of lectures and demonstrations on the part of the instructor entirely. Personally, I do not believe that the student can possibly get a great deal out of a course conducted in this manner. The student loses a great deal of the information presented as well as the training in actually operating the equipment. On the other hand, a course in which the student spends all of his time in the laboratory is not to be commended as there are many things to be learned regarding methods, special equipment, tool, etc., which can best be learned by lectures from the instructor. A combination of the above two methods gives the greatest results for the time allotted to a course. Our classes here are conducted along these lines. Short lectures and demonstrations are given at the beginning of the period, followed by actual operation by the students. Much time is saved by these lectures, and it is possible to cover a great deal more work.

In planning any course of study, the desired abjectives must be kept in mind, and there should be no tendency to present a course similar to those presented in trade schools. Such schools frequently endeavor to give engineering work, but such practice is not to be desired, as the object and scope of trade schools and engineering colleges are entirely different, and there is a definite field for each type of instruction.

Shop courses given here are presented during the sophomore and junior years, and it has been our experience that this arrangement proves very satisfactory. Freshmen are hardly prepared for the type of work that should be presented, and it comes too early in their curriculum to be correlated satisfactorily with some of their later work. By completing the work in their junior year, they have the benefit of this experience in their design and other senior courses.

It is our aim, so far as possible, to correlate the shop work with the other courses presented. In this respect, the student receives training in reading detailed drawings, special mechanisms of machines are discussed, shop nomenclature is considered, and many other things are taken up which will be of benefit to the students in their work in mechanics, machine design and management. In the latter course, which all mechanical and industrial engineers are required to take, we further round out their shop work by taking

up such subjects as production planning, wage systems, factory lay-out, special equipment and processes not covered in the shop work, materials handling equipment, and many other phases of factory operation. This course ties in the shop work with the other activities of an industry, and gives the engineer a clear conception of its importance and relationship to other departments.

In reviewing courses presented elsewhere, there seems to be a general consensus of opinion that shop work is desirable for mechanical, electrical, aeronautical, textile, and industrial engineering. Civil, chemical, mining and architectural engineeering courses vary considerably in their requirements, and in many cases, shop work is not required at all in the above courses. These courses obviously do not require as much shop work as those mentioned in the first group, but to eliminate it entirely has occasioned much discussion. It would appear desirable for all graduate engineers to have some training in shop work, as a large proportion of our graduates eventually enter industrial work where a knowledge of this work will prove valuable to them. Shop courses also train the student in accuracy, which is one of the finest qualities an engineer can have. It challenges his skill, and creates a desire for excellence in personal performance. It gives him a practical viewpoint which is an important adjunct to the theoretical training he receives. It puts him in a much better position to appreciate the practical man with whom he will be associated when he leaves college. These points are essential to all engineers, and combined with the actual training that he receives in the shop laboratory with materials, processes and equipment, this work cannot help but be an asset to the graduate engineer.

When the student leaves college, he must necessarily go through some sort of an orientation process. In practically all lines of endeavor, he has to start at the bottom and work up the ladder of achievement alongside of those who have not had the advantages of training that he has had. Many industries put the young engineer through an intensive training course in order to assist him in finding his place, realizing that he must first have special training and a practical viewpoint of their line of endeavor before he can be of great service to them. General knowledge of materials and production equipment on the part of the young engineer is expected by industry. They do not expect to get skilled men, but they do assume that they have a fundamental knowledge of engineering equipment, processes and principles. Shop work does much to prepare the student for his later work, and assists him in finding his place. With all the developments and progress in industry as it exists today, this work becomes increasingly valuable, and, if anything, should be given more and more consideration in our engineering curricula.

SECTIONS AND BRANCHES

Second Annual Meeting of Pacific Northwest Section, University of Washington, Seattle, Washington, April 6 and 7, 1934

The second annual meeting of the **Pacific Northwest Section** was held on the University of Washington Campus, on Friday and Saturday, April 6 and 7, 1934. Delegations from Montana State College, University of Idaho, Oregon State College and Washington State College arrived and registered Friday afernoon. There were present in all thirty teachers from the visiting schools. It is interesting to note that the three delegates from Montana State College traveled a distance of nine hundred miles to get to the meeting place. The least one-way distance traveled by any of the delegations was two hundred and ninety miles.

Dinner was served to sixty delegates and members of the local engineering faculty in the Men's Faculty Club. President Winkenwerder of the University of Washington gave an address of welcome. Following the dinner a technical and business session was held in the auditorium of Guggenheim Hall. Dean Tyler of the University of Washington presented a paper on "The Problems of Outside Technical Work on the Part of Faculty Members." He discussed the "Code Governing Outside Technical Work of the Faculty of the University of Washington" which has just recently been put into effect. Professor Milnor Roberts gave an informal talk on the high lights of the S. P. E. E. convention at Chicago and the summer school at Madison.

At the business session it was voted to extend an invitation to the College of Applied Science of the University of British Columbia to become associated with the Pacific Northwest Section. An invitation from Oregon State College to hold the next section meeting at Corvallis next spring was accepted. The following officers were elected for the ensuing year:

Chairman—Acting Dean Dearborn, O. S. C.
Vice-chairman—Professor B. T. McMinn, U. of W.
Secretary—Professor G. W. Holcomb, O. S. C.

Saturday morning from 8 to 10 A.M. was given over to inspection of the University of Washington laboratories and personal conferences. The second session, Vice-chairman Buchanan presiding, convened in Guggenheim Hall at 10 A.M. for the following program:

Lecture, Recitation and Laboratory Method of Teaching Engineering Mathematics, Prof. W. D. Tallman, M. S. C.

Discussion, Dr. A. F. Carpenter, U. of W.

Laboratory Report Standards, Prof. A. L. Albert, O. S. C.

Discussion, Miss Hall and Professor Hoard, U. of W.

Changing Emphasis in Engineering Shops, Prof. G. S. Schaller, U. of W.

Discussion, Prof. H. F. Gauss, U. of Idaho.

About sixty had lunch together at the University of Washington Commons.

The third session, held also at Guggenheim Hall, Chairman Sloan presiding, began at 2:30 P.M. and continued until after 5 P.M. The following papers which were presented proved to have much general interest and called forth considerable discussion.

A Seminar for Engineering Students, Prof. J. H. Johnson, U. of Idaho.

Discussion, Dr. Magnusson, U. of W.

The Functions of a Faculty Committee on Educational Policies, Dean Cobleigh, M. S. C.

Columbian Basin Project, Prof. H. E. Phelps, W. S. C.

About seventy were present at the final meeting which was an informal dinner for the members and their ladies, at which Dean Tyler presided. Excellent music was furnished by a trio from the Department of Music. Professor J. P. Harris of the Political Science Department, University of Washington, gave a very interesting talk on Municipal Management and Engineering. He traced briefly the history of the development of municipal management in this country and brought out the increasing importance of the part which the engineers have taken in its later development. Approximately one-half of the present city managers in the United States have been drawn from the ranks of the engineeers, he stated.

E. R. WILCOX,
Secretary.

The third meeting of the **Purdue Branch** for the year 1933–34 was held in the lecture room of the Michael Golden shops on the Purdue Campus Tuesday evening, February 27, 1934, at 7:30 P.M. The meeting, with Justus Rising of the Department of Practical Mechanics presiding, was attended by thirty-six persons.

The address of the evening was delivered by Mr. Horace B. Hench, B.S., M.E., a Consulting Engineer of the City of Chicago. His subject was "Eoneering, The Science of Developing All Science to Fit the Needs of Mankind."

Mr. Hench brought to the meeting a new word—"EONEERING," and a number of new ideas which create for the engineering pro-

fession a vision of a super-engineer prepared to cope with engineering problems in a truly social fashion. The address is so full of well made points that a full quotation is included:

"Elimination of worry and fatigue should be the aim of the new scientific age. The machine age so-called has demonstrated the wealth of earth lying latent for men to exploit. Many crudities have been produced. In the effort to build machines to be economically successful, man for the most part so far, has had just that economic and no other factor in view. He has, in the pursuit of quick wealth, placed a greater burden upon himself in the operation of machines than the human structure is fitted to bear. There are signs that man is about to be subservient to the machine.

"Machines have been built for a specific purpose and then man has endeavored to fit himself to their operation. Some attention, of course, has been paid in a cursory manner to comfort of operation, but this has been done only in a hit or miss or what might be called a trial and error fashion. There have been few if any scientific attempts made to fit the machine to man. Arbitrary rules and customs have governed almost entirely. For example, the width of our railroads was arbitrarily established according to the space between the wheels of the ancient Roman chariot which was drawn by two or more horses, whereas our trains are drawn by a machine of many thousand horsepower.

"As a result of the unscientific development of machines, we have occupational diseases, a myriad of accidents and enormous waste and loss of manpower. This loss has reached the proportions, in automobile operation alone, of the deaths in the United States Army and Navy in all of our wars. And the automobile business is only a generation old. There is no arriving at anything like an accurate estimate of the losses to humanity caused by the machines built and used without scientific consideration of the human element. The man has been forced to try to fit the machine instead of the machine having been made to fit the man.

"Now it would not be true to say that all machines have been built entirely without regard for the necessities of the operators. Experiment after experiment and innovation after innovation have been tried in the automotive industry to fit the products for easier operation. But what is distinctly wrong with the whole machine age is the fact that scientific measures have not been taken to arrive at the desired results. The experts do not study men; they study machines. They do not arrive first at the scientific knowledge of the human skeleton, muscles, nerves, and senses. Their attention is devoted primarily to the machines. It seems only sensible that these experts should first study the human body. As a matter of fact, in the light of what we now know about fatigue elimination,

no engineer of the future will be fitted to design machinery without a good deal of anatomical and physiological knowledge.

"Engineers and designers should know what happens to the body when any muscles or sets of muscles are brought into constant play. They should learn that troubles come not so much from overstrain as from the toxic poisoning developed by this overstrain. They should start from this point in planning to overcome these overburdens. They will then know what not to do in the building of their machines, and this, it seems to me, is as important as knowing what to do.

"For instance, when a designer starts out to make the plans for a machine to do a certain work, he must familiarize himself with the object for which the machine is to be built. Then he starts to select the form and the materials for the machine. He finds out scientifically all that is known about these materials. He does not proceed by guess-work. He knows what each material will stand and what each wheel or shaft is for, and how strong it must be to do the work. He makes provision for so much oil to keep the machine from getting tired. In fact, he is perfectly scientific in his treatment of the building of the machine for the object for which it is designed.

"But has he any scientific knowledge of the most important factor, the human being who will operate the machine?

"Does a designer give the same attention to man that he does to the inanimate materials from which the machine is constructed? The answer now is: No. And yet the operator should be the first thing considered. We have been in the past considering only the perfecting of the machine for the job it is intended to do. We have not been considering the main thing. We have been adapting man to the machine and just hoping he could consume its products. We have not given the human factor due scientific consideration.

"Machines, and in fact any kind of mechanical contraption, which have helped the human race in the struggle up from savagery, have always caused more or less unnecessary trouble. The science of EONEERING should eliminate this completely.

"Some members of the human race today, in the darkness before the dawn of real science, think that humanity has come to the end. That is, many who are superficial thinkers have lost faith and given up to despair. They think that we have reached a point in the development of science where science itself is about to destroy everything. They seem to accept as almost certain the destruction of the civilization which has been developed in the last 100 years.

"They cannot see the way out. They have lost faith in the ingenuity of the human race and seemingly are content to go back

to the days of the pioneers. They fear the machine. They think that safety is to be found only in the destruction of science and a return to an agricultural life sans all the improvements which in the last 50 years have made this manner of life endurable. They only prove that, much as we boast of our progress, we may be living in the darkest age the world has ever known, for even educated people are getting away from common sense and listening to them. Some of them are even considered to be or to have been thinkers.

"However, humanity has never let anything master it yet. And the casual reader of history will tell you that the human race has been confronted with some real and some frightful calamities and problems in its comparatively short span here. Now that it has grasped some of the rudiments of science it seems only reasonable to believe that nothing should overcome it. For if it is true that the awkward advances we have made in science have been at great expense to us and caused us to take up a tremendous burden, is it not common sense to be confident that this same science can be called into service to lighten these burdens and this expense?

"The answer is eoneering. Build the machine to fit the man. Think what a lot of work this will make for the generations to come. Think of the great scrapping that is to take place in the temporary structures we have been erecting during the last few years. Think of the tremendous task confronting the human race in making over and making better practically all the appliances which have been introduced in the last century. The houses and buildings, means of transportation, industrial plants, all must be eoneered. They must be replaced according to the new science and replaced in such manner that they will not be temporary affairs but built so they will last for long periods.

"The Romans built aqueducts that are as serviceable today as they were 2,000 years ago. Are we today building aqueducts for permanency? Are we as scientific as the ancient builders? A quick replacement is not a sign of progress. It may be a confession of a lack of science in the first place. Or a lack of common sense or ability. We have been awkward and careless builders. Our science so far has been awkward and careless. We have had to spend too much for replacement and upkeep.

"It may be that the tremendous burdens placed upon us today by the awkwardness of science and the carelessness in its application have finally resulted in our depression. It may be that we do not yet use common sense in the application of our knowledge to our best advantage. On the other hand some declare that we have advanced so rapidly in science that we have lost all sense of proportion, and with our mass production have caused the greater part of the ills to which we are subjected now. They think

we are out of balance. Well, the truth is that we can never balance anything when we pay all our attention to only one side of the scale. When we build the machine up at the expense of the human being we are upsetting the balance. But if we build the machine to fit the human being we shall have balance. That is eoneering. It is also common sense.

"The world suffers, therefore, not from too much science or too much use of science. It suffers from the abuse of science. It suffers from the lack of science in the application of science; from underproduction of the things that are useful to humanity. It does not suffer from overpopulation but from underpopulation because more people are needed than are in the world now, to produce the things which science has shown us we can get for the use of mankind. These things consist of all manner of mechanical appliances, homes, buildings, transportation, accessories, manufactures, etc., which as yet have not been developed with enough regard to making them fit the human anatomy, physiology and mentality. If we should construct in a really scientific way, things to fit men, we should have to replace most of the buildings and appliances which have been built or manufactured in the last fifty years and this is a job which would require all the man power we shall have for ages to come. It will require all the manpower that the products of the earth, the sea and the air can support for a considerable period.

"Now, unless we can build and construct from an eoneering standpoint, that is with a view to permanency as well as utility, our progress will be slow and expensive because replacement costs are tremendous and wasteful.

"For instance our hard road program has been a tragedy. Although we have known for thousands of years the effects of frost, we have not built our roads to be impervious to this destructive influence. The Romans, however, two thousand years ago knew how. They showed us how to build with a view to permanency.

"Science has, it is true, developed rapidly in the last few years, but the science of the application of science has not developed. There is not the coöperation between scientists and those who are applying science that we need. The pure scientists have no, or very little, interest in the application of science, and those who are applying science are governed first by the question of whether what they are trying to accomplish will pay. The gap should be bridged. There will be no necessity to call a halt on science or the application of science when this closer coöperation is achieved and the proper attention paid to the anatomy, physiology and mentality of the human being through science governed by eoneering.

"When designs are made scientifically with due regard to the elimination of overstrain on any faculty of the human body, a design for a certain appliance should be perfect for the particular use to which the article is put as long as there is no change in the structure of the human body. This is likely to be for an eon because the human body has shown no signs of change since history was first recorded. The Venus de Melos has as perfect a figure as any that can be found today and I think you will agree that Aristotle does not suffer by comparison with our best minds now.

"Science has taught us how to arrive more quickly at perfection in the making of designs. The system of fatigue elimination upon which I have been working for many years is a part of eoneering and is based on the story told in the blood stream by overstrain. Designs made or based on a proper knowledge of anatomy are not subject to change. They are permanent in so far as the human element is concerned.

"It may be objected that no progress could be made without quick replacement. That position is not now supported by the facts. The science of eoneering can teach us how to progress without having to stop every little while and suffer agonies for having gone too fast. We do not need to progress by sprints. The human race has a long road to travel and should endeavor to go ahead without having to rest or slip back every little while. The ancients showed us how to progress sanely. We are still using many of their rules but we are not using their common sense. A change in design may not be a proof of progress but rather proof of the lack of common sense in the first place. Or it may be a lack of the use of science in the making of the design.

"Many have been alarmed at the strides made by science ahead of the practical application of science in the last few years. Many on the other hand are inclined to boast of the accomplishments of the age. Both these positions are untenable. I believe that we should severely criticize ourselves for our lack of intelligence in the use of science—for the almost unbelievable disregard of the amazing wealth opened up to us in the last few generations.

"We, seemingly, are like a lot of savages in the jungle, who have just slain a hippopotamus. They try to eat it all at once for they do not know how to preserve it. We are trying to use all our science at once for we seemingly have or know of no means of building for the future as well as for the present. We want to use all our science right now to perform we know not what. We have in many instances gone hog wild and then wonder why we are sick.

"In the practical application of science we must adopt a formula which will obtain for man and preserve for man the greatest benefits to be had from his scientific discoveries. The ancient

Romans developed and codified rules for practice of the law. Our lawyers study them today. The Roman code has lasted for nearly two thousand years. A scientific code is now become as necessary as was the Justinian Code. Such a formula is eoneering. Let me expand this.

"Eoneering is the science of developing all science and human activity to fit the needs of mankind. It is the science of the use of science for the betterment of the human race. When developed it will enable us to use our knowledge so that no harm, but only good, will result in the use of science. Ignorance of the results which may be expected when science is indiscriminately applied to human activities, may be the principal cause of the difficulties now afflicting the world. If science was eoneered much less trouble would be experienced.

"Applied science is in the forefront of the battle of the human being against the forces of nature. Our scientific discoveries from the time of the invention of fire until the present have not been productive of good alone for humanity. Fire was soon used to destroy the neighbor's dwelling. Hence the code against arson. Agricultural, hunting and building utensils were often used for murder, hence the code against manslaughter. Ships were soon used for piracy. The building arts were used not for forts alone but for taking them as well. Road-building opened up access to the territory of the enemy. Mining was used to sap the walls of enemy strongholds. Practically every advance made by man in his struggle against the forces of nature could be and has been used in battle against other men.

"So, too, is it in this present age. We do not need to go into the damage science enabled belligerent powers to cause each other in the last great war. We know that the next one is going to be even more terrible. So it is necessary that we arrive at some code for the government of science to make it render up the most good to the human race. This is what we must most concern ourselves with.

"What can be claimed for eoneering? What is it expected to do? Here it is in a few words.

It shows us how to eliminate worry.

It shows us how to govern the use of science.

It shows us how to build machines to fit us.

It will help prevent the government of science by greed.

It will reduce wastage of replacement to a minimum.

It will give us a sensible plan for the development of the earth's treasures.

"Years ago as one of the pioneers in the application of alloy

steel to locomotive design, we were concerned with the inertia forces of these parts at high speeds and the fatigue of materials.

"Later in my case I became interested in the study of the inertia forces of high speed automobiles as they affect human fatigue. Fatigue and leg tiring misery have always been accepted as part of the privilege of driving an automobile. I finally built a gauge to fit the anatomy of the leg and used this in place of the customary accelerator. With certain adjustments, fatigue, as we have experienced it, disappeared to a very large extent.

"In doing such research work, it became necessary to study anatomy, to arrive at movements that were anatomically correct. Likewise the study of physiological chemistry became imperative for an understanding of the cause and effect of mechanical design on the human body. There is an enormous literature on this subject but it is entirely medical and is practically disregarded by designers. Now, these early attempts took place many years ago. Through the succeeding years, in an uncharted field, I have built, step by step, a practical, workable foundation for this new science. Eoneering did not come into being overnight. It is the result of years of work in research and application.

"It is known, for example, that the constant use of any set of muscles will produce an excess of lactic acid referred to as muscle poison. This produces aches and pains; it also slows the brain and nerve reactions; normal coördination is impaired and its social implication means occupational disease and accident. The whole point of this is that men that know about the human body are doctors and the men who know about machines and materials are engineers. There is no regular way for engineers to learn about anatomy as a part of their engineering training, for none of the scientific schools carry an integrated course of anatomy and machine design. Eoneering is a common sense method for converging, by a process of integration, all the sciences into one supreme science.

"In conclusion: Technical education today deals in the science of materials and how to fit them together to be economically successful.

"The present and past practices of designers in their use of science have been devoted to the development of material things; and man has been forced to accept these products, fit himself to the machine, and adjust his mode of living and outlook on life to the effects of the machine.

"In the study of the history of science, it seems almost unbelievable, that there never has been a plan for the development and use of science, with man and human needs as the focal point around

which all development should center, to scientifically fit the machine and its products to man's uses.

"The code of eoneering gives promise of a new epoch in the history of the world. It in fact will make science the best servant of mankind.

"It is a practical, workable plan which establishes for the first time that all science, all technical education and all material products must be dealt with scientifically for the best use of humanity.

"It is conceivable that through eoneering we can evolve a wholly new result contributing to the comfort and stable progress of our world.

"The developments in the last few years have unquestionably proved that in no other way is there assurance of a peaceful and orderly progress for humanity."

"Scientific discoveries and human knowledge have so multiplied that man has built a material mass machine existence that has reached the point where it needs a directing influence.

"For thousands of years, men of all races have had and still have today, codes for the guidance of spiritual life. Man so far seems to have been unable to translate these basic truths into any workable plan that could be universally applied to the material side of everyday life.

"History discloses that in the conferences of nations that there has probably never been and is not now any common vehicle upon which all peoples can unite in a common purpose. The science of Eoneering supplies this vehicle. It is the universal code of material life for every human being regardless of race or class. Though it survives for an eon, one cannot add anything to the fundamental premise on which Eoneering is founded, namely, the integration of all science and human knowledge into one science with the human being and the needs of mankind as the focal point of all future development.

"Let us first consider the general problems confronting us today, so that we may better understand the function of this new science.

"Since cleanliness is next to Godliness, let us consider the bathtub. One accident claim out of 200 paid by one of the large insurance companies is for people slipping and falling while taking baths and showers. Since one should have no accident exposure in the privacy of one's own bathroom, it seems evident that the bathtub is a relic of antiquity in which the human element receives little scientific consideration. Eoneering points the solution to that problem.

"The same analysis, applied to most products used by man, discloses that practically everything that has been built lacks scientific consideration of the human element and should in time be replaced by products that are Eoneered.

"The future development of civilization will lie largely in the hands of technically trained men. We are only in the primary stage in the development of science and the products of science and machinery. The future of technical education according to the science of Eoneering should begin with the teaching of the medical knowledge of the human body, such as anatomy, physiology, psychology and physiological-chemistry, blending into this knowledge the fundamental principles of designing and building material products to fit the requirements of the human body scientifically. Economics must likewise be an integral part of Eoneering for it is not only important that we consider man scientifically in the design of things, but we must likewise in the future give due scientific consideration to the effect of the use of these products of science not only upon specific groups of people but on the well being of humanity as a whole.

"Medical science represents a vast knowledge about the human body and the effects of the use of man-made products upon the body. For instance, the medical world has long known that the mechanical process of seeing with the eyes consumes human energy —that eyestrain can and does make the entire body tired and interferes with its efficiency. Yet present illumination in homes, offices, factories, etc., has not been scientifically designed and installed with reference to the effect of the use of that illumination on the eyes or the human body. Why should designers practically disregard the knowledge of the medical world, when so many of us suffer from eyestrain?

"Railroad rails offer an ideal means of fast, safe and pleasurable transport. If passenger equipment had been built by Eoneers during the past twenty-five years to scientifically eliminate human fatigue and inconvenience, to fit these vehicles to man's best use, these transportation groups would not be in the position they are in today.

"Many truck drivers and men in industry suffer from kidney trouble, rheumatism and occupational diseases because of the overburdens placed upon them by the improper design of the machinery they operate. It is perfectly possible through Eoneering to eliminate by design the conditions which cause these physical disabilities.

"There is an immeasurable loss to humanity in industries today through occupational disease and accidents and loss of life and limb that can largely be prevented by the practical application

of the principles of Eoneering to the design of plants and equipment. When factories and equipment are completely Eoneered from the inception of the building, and the design of the machinery, to its installation and operation, industrial accidents and disease will be reduced to a very small percentage of what they are today. This will increase efficiency, contribute largely to the lowering of the ultimate cost of commodities, and improve the working and living conditions of all the people."

Following the address Mr. Hench answered questions for the meeting.

In general the audience was impressed by the sanity of Mr. Hench's views and made aware of the place in the engineering profession for persons trained in "Eoneering," but it was deemed impractical to install a course solely for training Eoneers. Most persons present were of the opinion that Eoneers should be trained engineers who had fitted themselves by supplementary study for dealing with engineering problems in an Eoneering way.

Mr. Hench stated that far-sighted commercial establishments at present are using Eoneering methods of attack in connection with the development of products for the use of man and further that at the present time he could place several men trained in Eoneering in responsible positions.

W. I. Freel,
Secretary.

The T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE DIVISION OF ENGINEERING DRAWING

FREDERIC G. HIGBEE, EDITOR

Visualization. "Most drawings are made for the purpose of transmitting an idea to someone else. The draftsman who makes the drawing must, first of all, be able to visualize the object he wishes to draw, and his mental picture of this object must be perfectly clear. He must also have the ability to record this mental picture or idea on paper as a drawing, in such form that it will be perfectly clear to any one skilled in the art of reading drawings."

The above quotation from the most recent contribution to the literature of descriptive geometry raises an interesting point. It is readily conceded that the ability to visualize,—either to create a mental image of that which is not drawn, or to create from a drawing an image of that which is drawn, or to translate into a drawing an image or an object,—it is an important and powerful trait. Dr. Mann in his researches has examined into and reported on this quality of the engineering mind, McCauley and others have devised tests to measure to what extent this quality of the mind is present, and some experiments have been made to ascertain to what extent (if any), courses in engineering drawing and in descriptive geometry actually develop or improve the power to visualize. But —and this is the point of interest—no one yet has proved, except negatively perhaps, that the absence of the power to visualize is a barrier to engineering success, or that the study of either engineering drawing or descriptive geometry will create in a mind, not already possessed of imaginative power, the ability to visualize.

It is a generally accepted fact that a mastery of engineering drawing and descriptive geometry improve this desirable quality of the engineering mind, that a knowledge of these subjects enable engineers to convey and record ideas; but when it comes to claiming that engineers *must* visualize, and that these subjects actually *produce* the power to visualize, a much larger issue is raised than there is proof to substantiate.

Important results might accrue from a study of this phase of visualization in relation to engineering.

NEW MEMBERS

BERGGREN, WILLARD P., Technical Assistant in Mechanical Engineering, University of California, Berkeley, Calif. H. B. Langille, C. F. Garland.

KURTZ, JOHN W., Head, Pre-Engineering Dept., Municipal University of Omaha, Omaha, Nebr. F. L. Bishop, Nell McKenry.

REICH, HERBERT J., Assistant Professor of Electrical Engineering, University of Illinois, Urbana, Ill. E. B. Paine, H. H. Jordan.

SEVERNS, WM. H., Professor of Mechanical Engineering, University of Illinois, Urbana, Ill. O. A. Leutwiler, C. H. Casberg.

SHULTZ, E. O., Instructor in Drawing, University of Minnesota, Minneapolis, Minn. O. M. Leland, Frederic Bass.

SWITZER, FREDERICK G., Professor of Hydraulic Engineering, Cornell University, Ithaca, N. Y. D. S. Kimball, P. M. Lincoln.

MACHINE DESIGN DIVISION

The following petition has been granted by the Council:

The teachers of machine design, who constitute the activity known as the "Machine Design Clearing House," hereby petition the Council of the Society for the Promotion of Engineering Education for the authorization of a Machine Design Division of the Society. We have almost 90 members in about 85 colleges and, as you know, are active in the discussion (by mail) of problems relating to the teaching of machine design.

The members of the Executive Committee of the group are:

Wm. Howard Clapp, Calif. Inst. of Tech.

John M. Foster, North Carolina State College.

O. A. Leutwiler, Univ. of Illinois.

Edgar MacNaughton, Tufts College.

Frank L. Eidmann, Columbia Univ., *Chairman.*

Our group has held well attended conferences at the last three annual meetings and has a program arranged for the Ithaca meeting.

Respectfully submitted,

FRANK L. EIDMANN, *Chairman.*

COLLEGE NOTES

Bucknell University.—Dean Dexter S. Kimball, Cornell University, delivered an address of title, "Modern Industry and the New Deal" to the students and faculty of Bucknell on April 11th. This address was sponsored by the Engineering Group in coöperation with the Artist Course Committee and was exceptionally well received by the entire community. During the forenoon, Dean Kimball gave a very informative and interesting discussion of "Technological Unemployment." About one hundred and fifty engineering students and faculty members were present for the latter address.

On April 27th, President William E. Wickenden, Case School of Applied Science, was the guest of the University and was the principal speaker at convocation held on this date. During the afternoon he was the guest of the engineering faculty at which time he addressed the group. At this meeting plans were made for the affiliation of the Technical Conference with the Society for the Promotion of Engineering Education. The Technical Conference is composed of faculty members in engineering, natural science, and mathematics. The group has been functioning for the past ten years, and holds weekly meetings for the discussion of problems of technical interest. It also sponsors several social events for the members during the school year.

The University offers five graduate fellowships which are not confined to any particular type of graduate work and are available to those who hold the Bachelor's Degree. The stipend is five hundred dollars each. There are also available ten University graduate scholarships, stipend consists of free tuition and are open only to graduates of Bucknell University. Engineering students are eligible for both fellowships and scholarships.

Howard University.—At their meeting held April 10, 1934, the Board of Trustees established a separately organized and administered educational division, to be called "The School of Engineering and Architecture," with a dean at its head. Until such time as graduate instruction in Engineering and Architecture can be given at Howard University, the School of Engineering and Architecture will confine its efforts to a sound undergraduate program and pursue the practice of directing its graduates to other institutions for advanced work.

Since 1911 and prior to the reorganization, the departments of

Civil, Electrical and Mechanical Engineering, as well as Architecture, have been under the College of Applied Science. The other departments of the College of Applied Science—Art and Home Economics—are to be merged into the College of Liberal Arts.

Lewis K. Downing, M.S.E., the present Acting Dean of the College of Applied Science, has been appointed to head the new school.

The University's new Heat, Light and Power Plant, to be completed during the early part of next year, has been specially designed to serve and will serve as a valuable addition to the laboratory facilities of the Departments of Engineering.

No further departments of instruction are to be added to the new school at present.

University of Illinois.—Professor Melvin L. Enger, a member of the University of Illinois faculty since 1907 and head of its department of Theoretical and Applied Mechanics since 1926, was named dean of the College of Engineering and Director of the Engineering Experiment Station of the University, by the Board of Trustees in session here April 11. Arthur Cutts Willard who was last month elected President of the University, has been serving as Acting Dean of the College of Engineering this year.

To fill the vacancy caused by the election to deanship of Enger, Professor Fred B. Seely, a member of the faculty since 1909, was named the Theoretical and Applied Mechanics Department head. Another vacancy, caused when President-elect Willard was promoted last fall to the engineering deanship, was also filled by the Board when it named Professor O. A. Leutwiler to head the Department of Mechanical Engineering. Willard was for years head of that division. Leutwiler has been a member of the engineering faculty since 1903 and has been professor of mechanical engineering since 1921.

All three of the new appointees hold degrees from the University of Illinois. All will assume their new duties July 1.

Dr. R. D. Carmichael, who has acted as dean of the Graduate School during the present year, and Dr. M. T. McClure who has served as acting dean of the College of Liberal Arts and Sciences for the same period, were both promoted by the Board to full deanships.

Enger the new engineering dean is a graduate of the University of Illinois and has received three degrees from this institution. He received the bachelor of science degree in civil engineering in 1906, the professional degree of civil engineer in 1911, and the degree of master of science in 1916.

Professor Enger's field of specialization has been engineering

mechanics and hydraulics. He has given particular attention to flow of fluids through pipes, nozzles, orifices, and valves, as well as centrifugal pumps for deep wells, and has conducted an investigation of the physical properties of cast iron pige. He is recognized as an authority in these fields.

He is in administrative charge of the research investigations in engineering materials at the University of Illinois, which include the important investigations of fatigue of metals, cast iron pipe, concrete walls, concrete columns, causes of failure of railroad rails, etc.

Professor Enger has been on the staff of the University since 1907. He was born in Decorah, Iowa, in 1881, studied at the University of Minnesota and finished his undergraduate work at the University of Illinois, being graduated with the degree of Bachelor of Science in Civil Engineering in 1906. He received the professional degree of Civil Engineer in 1911 and the degree of Master of Science in 1916. Following his graduation he spent one year with the Chicago, Milwaukee, and St. Paul Railroad. After his return to the University he served successively as Instructor in Theoretical and Applied Mechanics 1907–09, Associate 1909–11, Assistant Professor 1911–15, Assistant Professor of Hydraulics 1915–17, Associate Professor 1917–19, and since 1919 he has been full Professor. On the retirement of Professor A. N. Talbot he became Head of the Department of Theoretical and Applied Mechanics on September 1, 1926.

He has written two Engineering Experiment Station Bulletins (Nos. 48 and 105), 17 technical papers, 8 book reviews, and other articles. He is the editor and compiler of parts 1, 2, and 3 of International Correspondence Schools textbook on hydraulics 1928.

Professor Leutwiler's field of specialization includes both machine design and power plant design. In addition to his specialized work in machine design involving the mechanics of machinery, he has given particular attention to the growth and development of the modern power plant.

It is probable that there is no man in engineering education today who is more familiar with the operation and performance characteristics of modern power plants as they have existed during the past twenty-year period than Professor Leutwiler.

Professor O. A. Leutwiler was born in Highland, Illinois, in 1877 and was graduated from the University of Illinois in 1899. Following his graduation he held a fellowship in mechanical engineering for one year and he received the professional degree of Mechanical Engineer in 1900. For one year thereafter he served as draftsman with the Parlin Orendorff Company of Canton, Illinois, and later as Instructor of Mechanical Engineering at Lehigh

University from 1901–03. He returned to the University of Illinois in 1903 and served successively as Assistant Professor of Machine Design 1903–15, Professor of Machine Design 1915–21 and Professor of Mechanical Engineering Design since 1921.

As an author Professor Leutwiler has written: Elementary Machine Design, 1906; Mechanics of Machinery, Part I, 1907; Part II, 1908; Notes on Power Plant Design, 1913; rewritten and enlarged, 1932; Elements of Machine Design, 1917; Problems in Machine Design, 1923.

Professor Seely's field of specialization has been analytical mechanics and advanced mechanics of materials. He has given particular attention to the resistance and properties of materials.

He has been an unusually successful and brilliant teacher of mechanics in both the graduate and undergraduate field. His numerous books, bulletins, and papers are remarkable for their excellence as well as for their unusual clarity of expression.

Professor Fred B. Seely has been on the faculty since 1909. He was born in Chester, New York, in 1884, and was graduated from the Worcester Polytechnic Institute in 1907 with the degree of Bachelor of Science and he received the degree of Master of Science at the University of Illinois in 1915. Following his graduation from Worcester Polytechnic Institute he served as a draftsman and engineer for the Carpenter Steel Company from 1907 to 1908, as Instructor in Mechanical Engineering at Villa Nova College 1908–09, and was also in the Engineering Department of the DuPont Powder Company. Since 1909 he has been on the faculty of the University of Illinois successively as Instructor in Theoretical and Applied Mechanics from 1909 to 1915, Associate 1915–1917, Instructor in the United States School of Military Aeronautics (located at the University during the World War) in the summer of 1917, Assistant Professor 1917–19, Associate Professor 1919–22 and Professor since 1922.

He is the author of Analytical Mechanics for Engineers (with N.E. Ensign) 1921; Resistance of Materials, 1925; Advance Mechanics of Materials, 1931; second edition 1933; five Engineering Experiment Station Bulletins (Nos. 96, 105, 115, 195, and 211); and sixteen technical articles and reviews.

Massachusetts Institute of Technology.—In February forty instrument-carrying stratosphere balloons were released from Lambert Field, St. Louis, by Technology meteorologists. A month later twenty-eight had been found and returned to the Institute with their instruments intact. Under the direction of Professor Carl G. Rossby, the calibration of the meteographs is now going on.

The instruments were recovered in southern Illinois and In-

diana at distances varying from 75 to 150 miles from Lambert Field. Analysis of the first records to be received by the Institute indicate that the balloon rose to a height of 10.7 miles where the temperature was —64° Fahrenheit. Atmospheric pressure and humidity were also recorded. By air mass analysis of the upper atmosphere it is hoped eventually to develop a science of weather prognosis independent of more than local observations.

The balloon study is a continuance of work begun during the World War when Scandinavian forecasters could not get the usual weather reports from neighboring countries.

The addition next year of three new men to the staff was recently announced: Dr. Francis Bitter, research physicist of the Westinghouse Electric and Manufacturing Company, Dr. Joseph H. Keenan, '22, of Stevens Institute of Technology, and Dr. Robley D. Evans, of the University of California. Dr. Bitter joins the faculty as associate professor in the Department of Mining and Metallurgy. Dr. Keenan becomes associate professor of mechanical engineering, while Dr. Evans will be an assistant professor in the Department of Physics.

Dr. Bitter is noted for his application of the ideas of modern physics and atomic structure to the understanding of the mechanical and magnetic properties of metals. At Technology, he will be associated with an active group dealing with the theoretical and practical aspects of physical metallurgy.

Having received his doctorate from Columbia University, Dr. Bitter then spent two years as a National Research Fellow in physics at Princeton University and at the California Institute of Technology. During this period he specialized in theories of magnetism. During the past year he has carried on research at Cambridge University as a Guggenheim Fellow.

Dr. Keenan was graduated from Technology with the degree of bachelor of science in naval architecture and marine engineering in 1922. While a student at the Institute, he rowed on the varsity crew and was a member of the gymnasium team. Following his graduation, he joined the staff of the General Electric Company, where for five years he carried on research and experimental development in large steam turbine design. In 1928 he accepted his present post as assistant professor and chairman of the department of mechanical engineering at Stevens Institute of Technology.

Dr. Evans is a native of Nebraska, and was graduated from the California Institute of Technology in the class of 1928. The same institution awarded him the degree of master of science in 1929, and in 1932, that of doctor of philosophy. As an undergraduate, he received an Institute scholarship, and from 1925 to 1927 won the Blacker scholarships.

Rutgers University.—An impression of the gains made in the science of air conditioning is to be obtained from a study of the educational side of the industry, where next year's scientists are in the making. At Rutgers University, the University Extension Division, which sponsors one of the most practical courses in the field, reports students from thirty-six states and five foreign countries registered in home-study work and in air conditioning. Australia, Russia, France, China, and Canada are the nations represented.

While there exists an interesting diversity of students, viewed in the light of previous qualifications, occupations, and training, it is significant, Rutgers officials believe, that in the air-conditioning course, records show a remarkably high percentage of completions. Students in this course, it has been discovered, receive grades which place this program among the highest three in all home-study courses offered by the university. The average grade for all these students is close to ninety per cent.

Worthy of comment, also, is the fact that the majority of students in the course are employees of public utility companies. The students range in rank from executives seeking to remain abreast of changing conditions and improvements, to factory mechanics eager to learn the science of their craft. Nevertheless the group has been able to maintain an average performance rating of slightly more than ninety per cent.

Former education seems to have little correlation with the degree of effectiveness with which a student acquires both the fundamental and advanced principles of air conditioning. Graduates of the school of experience have done nearly as well, it appears, as graduates of some of the leading colleges in undertaking these studies in a pioneer field of engineering.

Officials of Rutgers have stated that seldom has a home-study course provided their registrar with a more eloquent or more interesting assortment of statistics. Adequate support has, accordingly, been given the assertion that home-study can be, and not infrequently is, the most effective source of technical training for the adult group in a civilization which yearly advances anew beyond the bounds of established human knowledge.

Southern Methodist University.—At the beginning of the second semester, Mr. John N. Edy, City Manager of Dallas since 1931, was appointed as lecturer in Municipal Administration. Mr. Edy is giving a three semester hour course open to senior and graduate students, which reviews the principles, practices and relationships underlying the administration of municipal affairs, with particular emphasis upon organization, budgetry practice, purchasing, per-

sonnel systems, research and performance standards, and executive supervision and control.

Mr. Edy is a graduate Civil Engineer from the University of Missouri, and has a Master of Arts degree from the University of California. Before coming to Dallas as its first City Manager, he was City Manager at Flint, Michigan, for one year, and at Berkeley, California, for seven years. He has previously given courses in Public Administration at the University of Southern California and at Leland Stanford University. Mr. Edy is a member of the American Society of Civil Engineers and the International City Managers' Association, of which he is past president.

BOOK REVIEWS

A Manual of Thesis Writing (For Graduates and Undergraduates). By ARTHUR H. COLE AND KARL W. BIGELOW. $.75, 5½" × 8½"; 48 pp. New York: John Wiley and Son, Inc.

To those who have known that simplicity in scientific writing is a good thing and have hoped that simplicity would be urged upon writers of scientific theses, this book will represent a not small victory. Professor Cole of Harvard University and Professor Bigelow of the University of Buffalo have compiled an important manual: important because they have insisted that the graduate and undergraduate students shall write simply, at least when their substance is scientific. Such advice as: "it is often of aid if the investigator frequently reminds himself that his readers will not be as familiar with his material as is he, and hence will be less quick to catch implications and nuances." And, "Moreover, the finished paper ought surely to possess that smoothness which makes perusal easy and holds the attention of the reader," is good advice to follow in a scientific paper or in a novel. Throughout the handbook the authors have called the thesis writer's attention to the easy and simple method of doing a thing. Concrete suggestion of the sort of filing cards to use, a plea for common sense with punctuation and the mechanics of a thesis, and a warning that "the thesis will be stronger if it possesses that unity which is the consequence of a firm devotion to a single main theme, and that coherence which flows from the arrangement of material in a clearly logical order," should be read and re-read by all students writing reports. Perhaps, however, the urging of felicity of expression is one of the chief values of the book. Professors Cole and Bigelow rightly say that it is possible to avoid all the elephant traps of "fine writing," unnecessary embellishments, and bragging Latinisms. Scientific thesis writing can be interesting and there is no reason why it should not be interesting, to the reader as well as to the writer. Simplicity of expression is a contributor to interest: the medium of expression should never get in the way of what is being said.

The simplicity and common sense they urge has been used by Professors Cole and Bigelow in assembling their manual. In the Introduction they say: "The ensuing suggestions are grouped in a sequence based on the order in which the various problems of thesis-work will ordinarily be encountered: those concerned with

the choice of subject, preliminary plans for procedure, preparation of a working bibliography, collection of data, preparation for composition, and the drafting of the thesis itself." And the *Manual* follows the plan plotted out. The paragraphs on Problems Prior to Composition would be valuable to students writing theses in fine arts, English, or education as well as in scientific courses. The authors have told why they make their suggestions; they have given suggestions which they know have worked to the constant help of the student.

To be sure, a somewhat fuller treatment of the planning of the composition might have been offered, especially since the Professors Cole and Bigelow admit that "The student finds his greatest difficulty in organizing his own evidence." It is doubtful that the authors' assumption of the students' knowledge of the rules and practices of composition covers this shortcoming. And perhaps the three pages covered with proofreader's symbols might better have been given to a skeleton plan of an actual scientific thesis. However, if the writer of a scientific thesis wants to learn about footnotes or quotations, about narrowing material or collecting notes, he will find his answer clearly and simply set down in this little blue book.

JENNINGS HAMMER.

Simple Structures—(SHEDD & VAUTER)—John Wiley & Sons.

This text considers the limitation of a student in learning structural analysis. While indicating other solutions to the problems presented, the authors concentrate on the application of the first principles only to the solution of all problems from the simple to the more complex types of statically determinate frames. Students in this subject frequently make the mistake of memorizing type solutions and methods for specialized frames, in fact, memory is sometimes the basis for their entire knowledge of the subject. Because of this the authors present problems in widely varying types of frames but showing the same basic principles for solution. The principles of graphical analysis are given in a separate chapter. This text is well adapted to the needs of a student for home study.

C. L. CRITCHFIELD.

TENTATIVE PROGRAM FOR CONFERENCE ON USE OF MODELS IN TECHNICAL EDUCATION AND RESEARCH *

HELD IN CONNECTION WITH THE ANNUAL MEETING, SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION, CORNELL UNIVERSITY, ITHACA, N. Y., JUNE 19, 20, 21, 1934

Tuesday, June 19th, Opening Session:

9:00 A.M. Registration.

10:00 A.M. Opening Session—

Address by National President, S. P. E. E.
Welcome to Cornell.
"The Laws of Similitude."

2:00 P.M. Structural Section—

"The Fundamental Principles of the Deformeter Method of Model Analysis."
"Photo-Elasticity—A Short Explanation of the Optical Principles Involved."
"The Various Types of Loaded Models and Some Problems to Which Their Use Is Adapted."

2:00 P.M. Hydraulic Section—

(A) *Mathematical*—
"Dimensional Analysis as Related to Hydraulic Model Studies."
(B) *Physical*—
"The U. S. Waterways Experiment Station and Its Equipment." (Movies and slides.)
"Iowa Institute of Hydraulic Research." (Movies and slides.)
"The University of Maine Laboratory."
"The Alden Hydraulic Laboratory, Worcester, Mass."

Wednesday, June 20th:

9:00 A.M. Structural Section—

"Illustrations of the Application of Loaded Models."

* This tentative program was received on May 8, after the May JOURNAL was in page proof. It is published for the information of those interested.

"The Place of Photo-Elasticity in Engineering Instruction."
"The Use of a Model of a Building Frame in a Course in Structures."
"Illustrating Structural Problems with the Deformeter Method of Model Analysis."
"Models and Their Use in a Course Treating the Mechanics of Materials."

9:00 A.M. Hydraulic Section—
"Laboratory Research on Bed Sediment."
"River Models—Their Laws and Field Verification."
"Model Studies of Erosion below Dams."

2:00 P.M. Structural Section—
"Suspension Bridge Models as Used in Research."
"Graduate Research Employing Photo-Elastic Methods."
"A Thesis on Torsional Problems—The Correlation of Structural Models and the Soap Film Analogy."
"The Use of the Deformeter in an Experimental Thesis—A Multiple Span Continuous Concrete Arch Bridge on Elastic Piers."
"The Experimental Analysis of Dams."

2:00 P.M. Hydraulic Section—
"The Hydraulics of Settling Basins."
"Studies of Filter Sands."
"Side Channel Spillways."

Thursday, June 21st:

9:00 A.M. Closing Session—
"The Present Trend in Engineering Education."
(a) Speaker from Structural Section.
(b) Speaker from Hydraulic Section.
A Review—"The Purpose of the Seminar; Has it been Accomplished?"

Speakers include—

W. E. Wickenden, President Case School of Applied Science
Hale Sutherland, Lehigh University
T. H. Evans, Yale University
J. C. Rathbun, College of the City of New York
M. M. Frocht, Carnegie Institute

George E. Beggs, Princeton University
Fred L. Plummer, Case School of Applied Science
K. C. Reynolds, Massachusetts Institute of Technology
H. D. Vogel, Corps Engineers
S. M. Woodward, University of Iowa
W. J. Sweetser, University of Maine
C. M. Allen, Worcester Polytechnic Institute
Hans Kramer, Vicksburg
Gordon M. Fair, Harvard University